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VEGETATIVE CHARACTERS AS AN AID TO THE IDENTIFICATION OF COMMON WEED SEEDLINGS IN LOWLAND RICE FIELDS [1/]

JUAN V. PANCHO, ELISEO A. BARDENAS, AND JOSE M. CAPINPIN

WITH THIRTY-ONE TEXT FIGURES

A total of 34 species of weeds common in lowland rice fields distributed in 30 genera and 15 families, including a key to their identification, is presented.

While engaged in the chemical control of weed seedlings in lowland rice fields, the writers found it desirable to conduct a study which could facilitate their identification. This paper presents the result of that study—a description of the vegetative characters of 34 species of young weeds, and a key to their identification.

In studying the seedlings, [2/] soils were collected from different parts of the Central Experiment Station and its vicinity and placed in culture drums (fig. 30). As far as possible, the soil was

Fig. 30.—*Weed seedling cultures.*

1/ Central Experiment Station Contribution No. 2083.

2/ Seedlings refer to those plants up to secondary leaf formation.

made to simulate the lowland conditions of rice fields. Seedlings were studied as they underwent developmental stages and were grown to maturity for identification. Herbarium specimens were prepared for each species and were deposited at the U.P. College of Agriculture Herbarium for future reference.

KEY TO VEGETATIVE CHARACTERS OF COMMON RICE WEED SEEDLING SPECIES

1. Cotyledon absent; young leaf circinate. — *Ceratopteris siliquosa*
1. Cotyledon present; young leaf not circinate.
    2. Cotyledon 1; leaves parallel-veined.
        3. Stems triquetrous;[3] leaves keeled. — *Cyperus iria and C radiatus*
        3. Stems laterally compressed or terete; leaves not keeled.
            4. Stems laterally compressed. — *Fimbristylis miliacea*
            4. Stems terete.
                5. Stems transversely zoned with purple. — *Echinochloa colonum*
                5. Stems all green.
                    6. Leaves terete, erect. — *Scirpus erectus*
                    6. Leaves flat, arching.
                        7. Young leaves rolled in the bud. — *Echinochloa crusgalli* and *E. crus-pavonis*
                        7. Young leaves flat, not rolled in the bud.— *Monochoria hastata* and *M. vaginalis*
    2. Cotyledons 2; leaves net-veined.
        8. Secondary leaves compound.
            9. Secondary leaves trifoliolate.
                10. Stems purplish; cotyledons caducous; leaflets obcordate. — *Desmodium triflorum*
                10. Stems pale green; cotyledons persistent; leaflets oblong. — *Crotalaria* sp.
            9. Secondary leaves pinnate.
                11. Cotyledons persistent.
                    12. Stems purplish; leaves closing when touched. — *Mimosa pudica*
                    12. Stems greenish; leaves not closing when touched. — *Cassia mimosoides*

3/ Glossary of terms used in this paper are found in Appendix 1.

11. Cotyledons caducous. — *Phyllanthus simplex*

8. Secondary leaves simple.

13. Stems exude milky sap when cut. — *Euphorbia hirta*

13. Stems not exuding milky sap when cut.

14. Primary leaves alternate.

15. Primary leaves orbicular to cordate, serrate. — *Melochia concatenata*

15. Primary leaves spatulate or elliptic-lanceolate, entire or serrulate.

16. Primary leaves spatulate, entire to serrulate. — *Sphaeranthus africanus*

16. Primary leaves elliptic-lanceolate, entire. — *Sphenoclea zeylanica*

14. Primary leaves opposite.

17. Stems glabrous.

18. Leaves 1 or 3-nerved.

19. Leaves 1-nerved.

20. Stems terete; primary leaves broadly elliptic.—*Ammania* sp.

20. Stems somewhat quadrangular; primary leaves oblong — *Bacopa floribunda*

19. Leaves 3-nerved. — *Glinus oppositifolius*

18. Leaves penninerved.

21. Stems green.

22. Basal portion of midribs pinkish. — *Jussiaea erecta*

22. Basal portion of midribs green.

23. Secondary leaves serrulate, broadly elliptic, often with purple blotch on upper surface. — *Ilysanthes antipoda*

23. Secondary leaves entire, oblong, without purple blotch. — *Rotala leptopetala*

21. Stems pinkish to purplish.

24. Secondary leaves obcordate,

reddish beneath. — *Phyllanthus niruri*

24. Secondary leaves otherwise, greenish beneath (the veins in *J. repens* often pinkish towards the base).
    25. Secondary leaves ovate to cordate. — *Jussiaea repens*
    25. Secondary leaves oblanceolate to spatulate. — *Ammania baccifera*

17. Stems puberulent.
    26. Leaves sessile. — *Bergia ammannioides*
    26. Leaves petiolate.
        27. Petiole as long as the blade. — *Ageratum conyzoides*
        27. Petiole shorter than the blade.
            28. Stems and underneath of leaves purplish; secondary leaves alternate. — *Gynura crepidioides*
            28. Stems and leaves green; secondary leaves opposite.
                29. Secondary leaves prominently veined. — *Heliotropium indicum*
                29. Secondary leaves obscurely veined.
                    30. Secondary leaves serrate. — *Synedrella nodiflora*
                    30. Secondary leaves entire.
                        31. Primary leaves glabrous, ovate. *Vernonia cinerea*
                        31. Primary leaves pubescent beneath, elliptic to ovate. — *Eclipta alba*

DESCRIPTION OF THE SPECIES

Ceratopteris siliquosa (L.) Copeland. (fig. 17)

Local name: [4/] *Pakong-roman* (Tag.).

Stems and leaves glabrous, light green, primary leaves oblong, succeeding leaves orbicular.

Common along dikes and canals.

Cyperus iria L. and *C. radiatus* Vahl. (fig. 6).

Local names: *Alinang, paiung, sudsud, taga-taga* (Bik.); *oko-kiang* (Bon.).

Stems glabrous, pale green, triquetrous. Leaves keeled, the tip pointed.

One of the most common and abundant weeds in rice paddies and canals.

Fimbristylis miliacea (L.) Vahl. (fig. 9).

Local names: *Agor, taulat, ubod-ubod* (Tag.); *gumi* (Pang.); *sirau-sirau* (Ilk.); *sirisibuyas* (Bik.).

Sheath at base closed, laterally compressed, glabrous throughout, green.

Abundant in rice paddies, canals, and dikes.

Echinochloa colonum (L.) Link. (fig. 5).

Local names: *Bulang, tiribuhan* (Tag.); *dalakayang, dukayang,* (Ilk.); *tumi* (Bon.).

4/ The abbreviations adopted for the various local dialects and languages were taken from Merrill's "An Enumeration of Philippine Flowering Plants."

Bag.	— Bagobo	Mag.	— Magindanao
Bik.	— Bikol	Mbo.	— Manobo
Bis.	— Bisaya	Pamp.	— Pampanga
P. Bis.	— Panay Bisaya	Pang.	— Pangasinan
C. Bis.	— Cebu Bisaya	Sbl.	— Sambali
S. L. Bis.	— Samar-Leyte Bisaya	Sp.	— Spanish
Bon.	— Bontoc	Sul.	— Sulu
If.	— Ifugao	Sub.	— Subanun
Ilk.	— Ilokano	Tag.	— Tagalog
Ig.	— Igorot	Engl.	— English
Iv.	— Ivatan		

Leaf sheath transversely zoned with purple; ligules absent; blade flat in cross section, the tip acuminate; young leaves rolled in the bud.

Very common and grows abundantly in rice paddies, dikes, and canals.

Scirpus erectus Poir. (fig. 29).

Local names: *Bitubituinan, gumi* (Tag.); *paratupit* (Ilk.).

Stems and leaves glabrous, terete; the leaves erect, sheathing below.

Common along dikes and canals.

Echinochloa crusgalli (L.) Beauv. and
E. crus-pavonis (HBK.) Schult.

Local names: *Daua-daua, Bayokibok, daua-dauahan* (Tag.); *dauana* (Mbo.); *lagtom* (Bik.); *sabsablug, sabsabug* (Bon.).

Similar to *E. colonum* but is easily distinguished by the absence of purple blotch on the sheath.

Habit as in *E. colonum*.

Monochoria hastata (L.) Solms and
M. vaginalis (Burm. f.) Presl. (fig. 11).

Local names: *Biga-bigaan, gabing-uak, kalabua* (Tag.); *gabi-gabi* (P. Bis., C. Bis.); *hahalung, hakhaklung* (If.); *lagtang, upi-upi* (Bik.); *kosol-kosol, payan-payan* (Bis.); *bil-lagut, lapalapa* (Ilk.); *saksaklung* (Ig.); *saksakong* (Bon.).

Leaves flat, sheating below, glabrous on both surfaces, linear, the apex acute, 10 mm. long, 1 mm. wide; succeeding leaves broader, the base finally hastate (in *M. hastata*) or cordate (in *M. vaginalis*).

Desmodium triflorum (L.) DC. (fig. 25).

Local names: *Kaliskis dalag, pakpak-lañgau* (Tag.).

Stems purplish, glabrous to puberulent. Primary and secondary leaves tri-foliolate leaflets obcordate, glabrous with few long hairs along the margins.

Common along dikes and canals.

Crotalaria sp. (fig. 8 & 31, no. 103).

Local name: *Latuk-latukan* (Tag.).

Stems pale green, glabrous. Cotyledons 1.5 to 2 inches from the base, shortly petioled, opposite, oblong, glabrous, entire, 18 mm. long, 10 mm. wide. Primary leaves elliptic, simple, 35 mm. long, 10 mm. wide, the tip emarginate. Succeeding leaves alternate, tri-

foliolate.

In rice paddies and canals.

Mimosa pudica L. (fig. 4).

Local names: *Babain, dilgansusu* (Ilk.); *damohia* (Tag.); *harupai, kiromkirom* (S. L. Bis.); *huya-huya* (Bis.); *makahia* (Pang., Tag.); *sipug-sipug* (Sub.); *tuyag-huyag* (P. Bis.); *torog-torog* (Bik); sensitive plant (Engl.).

Stems purplish, glabrous to puberulent. Cotyledons glabrous, elliptic, the base cordate. Stipules present, slender, 1 mm. long. Leaves alternate, even-pinnate, closed when touched.

Very common along dikes and canals.

Cassia mimosoides L. (fig. 19).

Local names: *Karagain* (Bag.); *kilkidis* (Bon.).

Stems green, glabrous. Cotyledons opposite, elliptic. Leaves alternate, pinnately compound, glabrous; leaflets elliptic, 6 mm. long, 2 mm. wide, glabrous.

Common in rice paddies.

Phyllanthus simplex Retz. (fig. 14).

Local names: *Kaya-an, kayut-bulan* (Bag.).

Stems greenish to purplish toward the base, glabrous. Primary leaves simple, glabrous, elliptic, entire, shortly petioled, 3 mm. long, 2 mm. wide. Secondary leaves pinnately compound, alternate; leaflets obovate, 7 mm. long, 3 mm. wide, the midrib prominent.

Seldom seen in rice paddies but common along dikes and canals.

Euphorbia hirta L. (fig. 27).

Local names: *Bambanilag* (If.); *bolobotonis, saikan, butobutonisan* (Tag.); *bolobotonis, magatas, malis-malis, sisiohan* (Pamp.); *bobi, tababa* (Bis.); *botonis, maragatas* (Ilk.) *bugayau* (S.L. Bis.); *gatas-gatas* (Bis., Tag.); *pansi-pansi, soro-soro* (Bik.); *patik-patik* (Sul.); *piliak* (Sub.); *tairas* (Iv.); *tauataua* (P. Bis.); *teta* (Bon.); snake weed (Engl.).

Stems puberulent to densely pubescent towards the apex, purplish, exudes milky sap when cut. Primary leaves opposite, ovate to orbicular, somewhat purplish, pubescent, 2.5 mm. long, 2 mm. wide, margin entire or somewhat undulate. Succeeding leaves elliptic to ovate, pubescent, the base oblique.

Not common in rice paddies but abundant on dikes and canals.

Melochia concatenata L. (fig. 16).

Local names: *Botobotonis* (Ilk.); *botobotonisan, sambang-gala*

Stems green, glabrous to puberulent. Leaves alternate, glabrous, orbicular to cordate, serrate, 7 mm. long, 6 mm. wide, the petiole as long as the blade, puberulent, veins prominent on both surfaces.

Common along rice paddies.

Sphaeranthus africanus L. (fig. 7 & 31, no. 107).

Local names: *Botobotonis* (Ilk.); *botobotonisan, sambong-gala* (Tag.); *talatabako, tarutabako* (Bis.).

Stems pale green, glabrous. Primary leaves alternate, glabrous, entire or sometimes serrulate, spatulate, 4 mm. long, 2 mm. wide, veins on upper surface obscure, prominent on the lower. Secondary leaves elliptic, much larger.

Seedlings are similar in appearance to tobacco (*Nicotiana*) seedlings.

Sphenoclea zeylanica Gaertn. (fig. 24 & 31, no. 104).

Local names: *Mais-mais* (P. Bis.); *silisilihan* (Tag.).

Stems pale green, glabrous. Primary leaves alternate, elliptic-lanceolate, glabrous, entire, 5 mm. long, 1.5 mm. wide. Secondary leaves as the primary ones, but much larger, shinny on both surfaces.

Very common in rice paddies.

Ammania sp. (fig. 12).

Similar to *Bacopa floribunda* from which it differs in having darker green and broadly elliptic leaves.

Very common in rice paddies.

Bacopa floribunda (R. Br.) Wettst. (fig. 12).

Stems somewhat quadrangular, green, sometimes purplish, glabrous, stipulate. Primary leaves opposite, oblong, entire, glabrous, 5 mm. long, 2 mm. wide. Succeeding leaves much larger, decussate, oblong to oblong-elliptic, the midrib prominent.

Common in rice paddies and canals.

Glinus oppositifolius (L.) A.DC. (fig. 3 & 31, no. 101).

Stems greenish or sometimes purplish, glabrous. Primary leaves opposite, entire, oblong-ovate, glabrous, 8 mm. long, 2 mm. wide. Succeeding leaves much larger, 3-nerved, decussate, the veins green, sometimes purplish.

One of the common weeds in rice paddies, dikes, and canals.

Jussiaea erecta L.

Local names: *Balansuit* (Mag.); *malapako, tubong-talapang* (Bik.); *pachar-pachar* (Sul.); *palangdisin* (Ig.); *talangkau* (Ilk.); *tayilakton* (Tag.).

Similar to *J. repens* from which it differs in being greenish throughout except the basal portion of midrib which is pinkish. Leaves oblong-ovate.

Habit as in *J. repens*.

Ilysanthes antipoda (L.) Merr. (fig. 2 & 10).

Stems greenish, glabrous. Primary leaves opposite, glabrous, entire, ovate, 3.1 mm. long, 1.5 mm. wide. Secondary leaves similar to primary ones but much larger, entire to serrulate, often with purple blotch on the upper surface near the base, veins prominent beneath.

Very common in rice paddies.

Rotala leptopetala (Blm.) Koehne (fig. 26).

Stems glabrous, greenish. Primary leaves opposite, glabrous, linear, 3 mm. long, 1 mm. wide. Succeeding leaves oblong, much larger than primary leaves, decussate, the midrib prominent, somewhat canaliculate above.

One of the common weeds in lowland rice fields.

Phyllanthus niruri L. (fig. 28).

Local names: *Kurukalunggai, surusampalok, turutalikod* (Bik.); *malakirum-kirum* (S. L. Bis.); *ñgingihel* (If.); *sampasampalukan* (Tag.); *San Pedro* (P. Bis.); *talikod, taltalikod* (Ilk.).

Stems purplish, glabrous. Primary leaves opposite, elliptic, reddish beneath; succeeding leaves obovate, the veins prominent beneath, reddish.

Common along dikes and canals.

Jussiaea repens L. (fig. 1 & 31, no. 102).

Local names: *Gabi-gabi* (Mag.); *sigang-dagat* (Tag.).

Stems pinkish, glabrous. Primary leaves opposite, ovate, 3 mm. long, 2 mm. wide, the petiole as long as the blade. Secondary leaves ovate to cordate, glabrous, 8 mm. long, 5 mm. wide, decussate, veins prominent beneath, often pinkish toward the base.

Common in rice paddies and canals.

Ammania baccifera L. (fig. 23).

Local names: *Apoy-apoyan* (Pang., Tag.); *bias-pugo* (Tag); *parapitangit* (Pamp.); *blistering Ammania* (Engl.).

Similar to *R. leptopetala* from which it differs in having purplish stem and oblanceolate to spatulate primary leaves.

Very common in rice paddies.

Bergia ammannioides Roxb. (fig. 22).

Stems greenish, puberulent. Primary leaves opposite, sessile, glabrous, entire, ovate, 4 mm. long, 3 mm. wide. Secondary leaves opposite, ovate, puberulent beneath, 9 mm. long, 6 mm. wide, veins prominent beneath.

Common along dikes and canals.

Ageratum conyzoides L. (fig. 13).

Local names: *Asipukpuk* (Pang.); *bahu-bahu* (Sul.); *bahug-bahug* (P. Bis.); *budbuda* (Ig.); *bulak-manok, damong pallas, kolokong-kabayo* (Tag.); *kalkalding, pagpagai, taindikaldi* (Bon.); *kamubuag* (Iv.); *kulong-kogong-babae* (Bik.); *siñgilan* (Ilk.); goat weed (Engl.).

Stems greenish to purplish towards the base, hirtellous to hirsutous. Primary leaves opposite, entire, hirtellous, ovate. 2.5 mm. long, 2.5 mm. wide, the petiole as long as the blade. Secondary leaves similar to primary ones but much larger. Succeeding leaves ovate, crenate to serrate, pubescent.

One of the common weeds along dikes and canals.

Gynura crepidioides Benth. (fig. 18).

Stems purple, glabrous to puberulent towards the tip. Primary leaves alternate, glabrous, entire, purplish below, ovate, 6 mm. long, 4 mm. wide, the petiole about 1/3 the blade. Secondary leaves alternate, subserrate, purple below, 12 mm. long, 5 mm. wide.

Common along canals and dikes.

Heliotropium indicum L. (fig. 21)

Local names: *Buntot-leon* (Tag., Bik.); *higad-higaran, hinlalayon, kuting-kutingan, malakudkuran, trompa ñg elepante* (Tag.); *ikog-ikog-sang-kuti, kabra-kabra, kambra-kambra* (Bis.); *ikoi-pusa* (Sbl.); *makabra, punta-elefante* (P. Bis.); *pengñga-pengnga* (Ilk.); *trompa elefante, bigotitos, lengua de sapo* (Sp.) Indian heliotrope (Engl.).

Stems greenish, puberulent. Primary leaves opposite, elliptic,

entire, the blade glabrous with puberulent petiole, 8 mm. long, 4 mm. wide. Secondary leaves opposite, prominently penninerved, 13 mm. mm. long, 8 mm. wide.

Comon along dikes and canals.

Synedrella nodiflora (L,) Gaertn. (fig. 15).

Local name: *Fantankuen* (Ilk.).

Stems green, glabrous to puberulent towards the tip. Primary leaves opposite, ovate, 6 mm. long, 4 mm. wide, the petiole about 1/3 the blade. Secondary leaves opposite, subserrate, 12 mm. long, 5 mm. wide.

Common along canals and paddies.

Vernonia cinerea (L.) Less. (fig. 20).

Local names: *Agas-moro* (Ilk.); *bulabod* (Sub.); *Kolong-kugon* (S. L. Bis.); *magmansi* (Pang.); *sagit* (Bon.); *tagulinau, kagulinai* (Tag.).

Stems purplish, puberulent. Primary leaves opposite, glabrous, entire, oblong-ovate, 3 mm. long, 1.5 mm. wide. Secondary leaves orbicular to elliptic, 5 mm. long, 2.1 mm wide; veins on the lower surface prominent, not so on the upper.

Common along dikes and canals.

Eclipta alba (L.) Hassk. (fig. 31, no. 101).

Local names: *Higis-manok* (Tag.); *karimbuaya, tinta-tinta, tultulisan* (Ilk.); *pia* (If.); *vayod* (Iv.); *verba de tajo* (Sp.).

Stems pale green to purplish, puberulent. Primary leaves opposite, elliptic to ovate, pubescent beneath, entire, 4 mm. long, 2 mm. wide. Secondary leaves as the primary ones, entire or sometimes ciliate, 12 mm. long, 5 mm. wide.

Very common in rice paddies, dikes and canals.

APPENDIX I

Glossary of Terms

acuminate—tapering to a prolonged point; attenuate.

acute—distinctly and sharply pointed but not drawn out.

caducous—falling off early or prematurely, as the sepals in some plants.

cordate—heart-shaped; said of leaves having the petiole at the

broader and notched end.
crenate—said of a margin with rounded or blunt teeth.
decussate—in pairs alternately crossing at right angles.
elliptic—a flat part or body that is oval and narrowed to narrowed ends.
emarginate—with shallow notch at the apex.
glabrous—smooth, devoid of pubescence or hair of whatsoever form.
hastate—halberd-shaped, sagittate, with the basal lobes turned outward.
hirsute—with rather rough or coarse hairs.
hirtellous—softly or minutely hirsute or hairy.
keel—a central dorsal ridge.
ligule—a strap-shaped organ or body; particularly a strap-shaped corolla, as in the ray flowers of compositae; also a projection from the top of the sheath in grasses and similar plants.
linear—long and narrow with margins parallel or nearly so.
oblanceolate—inverted lanceolate.
oblong—longer than broad with the margins nearly parallel.
obovate—reversed ovate, the distal end the broader.
orbicular—flat with a circular outline.
ovate—shaped like a longitudinal section of hen's egg, the broader end basal; applied to ovoid.
penninerved—nerved in a pinnate manner.
pinnate—feather-formed, as with the leaflet of a compound leaf placed on either side of a rachis.
puberulent—somewhat or minutely pubescent.
pubescent—covered with short soft hairs or down.
serrate—with sharp teeth on the margin pointing forward.
sessile—without a stalk of any kind, as a leaf without a petiole.
sheat—any long or more or less tubular structure surrounding an organ or part.
spatulate—spatula-shaped.
stipule—one of the pairs of appendages borne at the base of the leaf in many plants.
terete—circular in transverse section.
trifoliolate—having a leaf or leaves of 3 leaflets, as most clovers.
triquetrous—with 3 salient angles.
undulate—wavy, repand.

Fig. 1-13.—*Weed seedlings*: *fig.* 1, Jussiaea repens; *fig.* 2 *and* 10, Ilysanthes antipoda; *fig.* 3, Glinus oppositifolius; *fig.* 4, Mimosa pudica; *fig.* 5, Echinochlea colonum; *fig.* 6, Cyperus iria *and* C. radiatus; *fig.* 7, Sphaeranthus africanus; *fig.* 8, Crotalaria *sp; fig.* 9, Fimbristylis miliacea; *fig.* 11, Monochoria hastata *and* M. vaginalis; *fig.* 12 Ammania *sp.; fig.* 13, Ageratum conyzoides.

Fig. 14-29.—*Weed seedlings*: *fig.* 14, Phyllanthus simplex; *fig.* 15, synedrella nodiflora; *fig.* 16, Melochia concatenata; *fig.* 17, Ceratopteris siliquosa; *fig.* 18, Gynura crepidioides; *fig.* 19, Cassia mimosoides; *fig.* 20, Vernonia cinerea; *fig.* 21, Heliotropium indicum; *fig.* 22, Bergia ammannioides; *fig.* 23, Ammania baccifera; *fig.* 24, Sphenoclea zeylanica; *fig.* 25, Desmodium triflorum; *fig.* 26, Rotala leptopetala; *fig.* 27, Euphorbia hirta; *fig.* 28, Phyllanthus niruri; *and fig.* 29. Scirpus erectus.

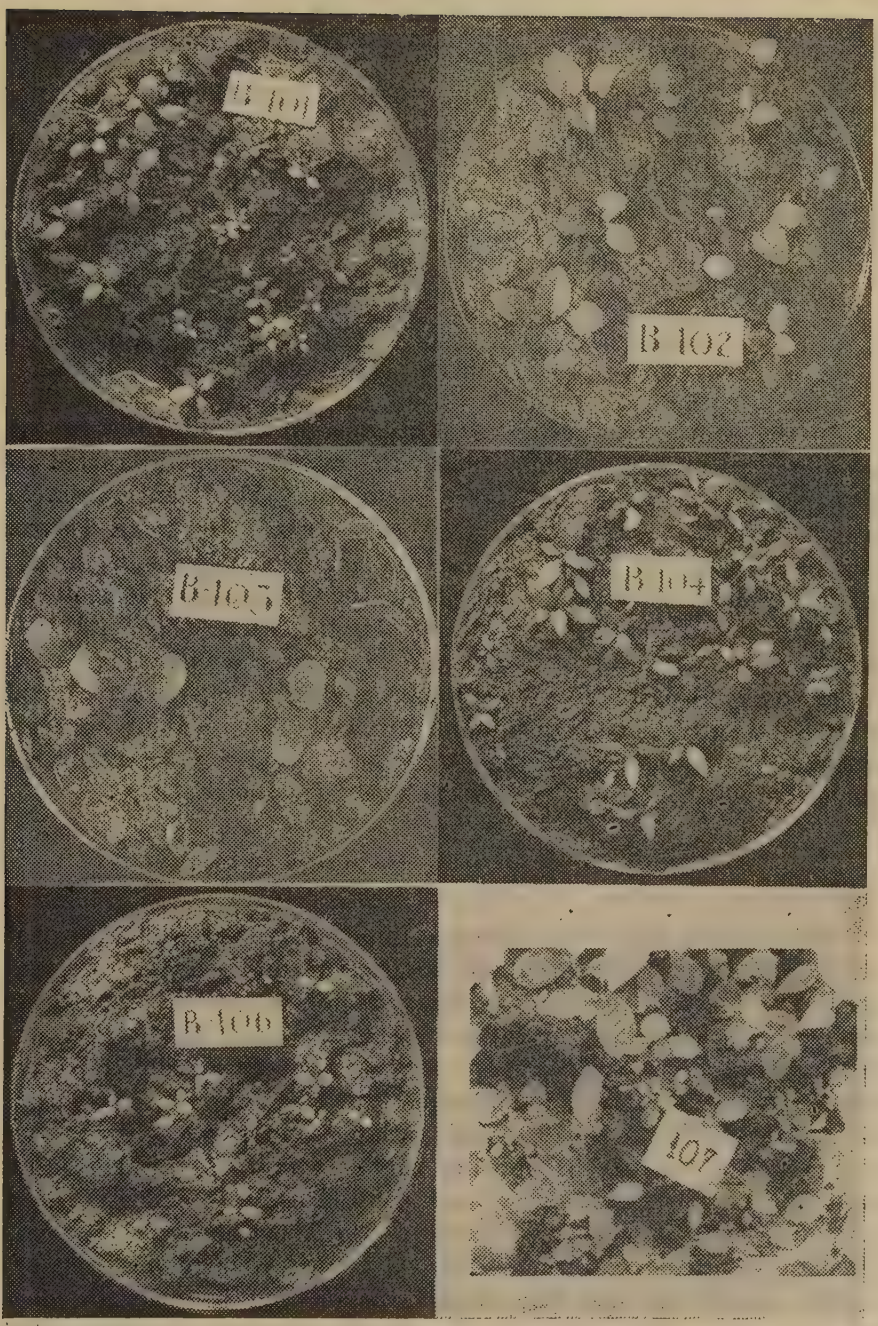

Fig. 31.—*Weed seedlings*: *No.* 101, Glinus oppositifolius; 102, Jussiaea repens; 103, Crotalaria *sp.;* 104, Sphenoclea zeylanica; 106, Eclipta alba; *and* 107, Sphaeranthus africanus.

HAPLOIDY IN BOUGAINVILLEA [1]

JUAN V. PANCHO AND JOSE M. CAPINPIN

WITH FOUR TEXT FIGURES

This is a case report on haploidy in Bougainvillea glabra 'Pequinito'. Cytological analysis of meiosis revealed 17 univalent chromosomes verifying the basic or haploid number.

A haploid plant of Bougainvillea was apparently due to parthenogenesis, which results from the development of the egg nucleus. By inferential evidence, it was postulated that in natural crossing or hybridization, the embryo was stimulated by the pollen which, however, did not affect fertilization.

In the course of routine cytological studies of meiosis in the *Bougainvillea* (Pancho, *et al.*, 1960), the writers were attracted by the paucity of pollen in *B. glabra* 'Pequiñito'. The plant exhibited almost complete sterility and was characterized by small leaves. The cymes had four to six flowers (normally in groups of three). The apparent dwarfism of the plant, the diminutive characteristics of its morphological parts, and the insufficiency of its well formed pollen grains led to the suspicion that the plant may be a chromosomal aberrant. An examination of the pollen mother cell (PMC) preparations of this plant revealed 17 univalent chromosomes at metaphase, verifying its haploid condition. Later, this conclusion was confirmed by somatic counts in the root-tips.

DESCRIPTION OF THE HAPLOID PLANT

The haploid plant was an exact duplicate of the diploid except that it was never more than half the size of the latter in all plant parts. These were especially noticeable in the flowers and leaves and the highly sterile cymes. In stature, the plant is of the dwarf type (fig. 1). Its dwarfing is partly caused by a shorter internode length. Its main stalk is smaller in circumference than that of the normal diploid. It grows rather luxuriantly, putting out many axillary branches. Cuttings made from these branches are easily rooted. The anthers do not dehisce and the pollen formed in them is empty, evidently because of the abortion of microspores although an occasional filled grain is found. The pollen appears slightly smaller in size than diploid pollen and it generally does not stain with anilin lacto-phenol. It was observed, however, that

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1/ Central Experiment Station Contribution No. 2804

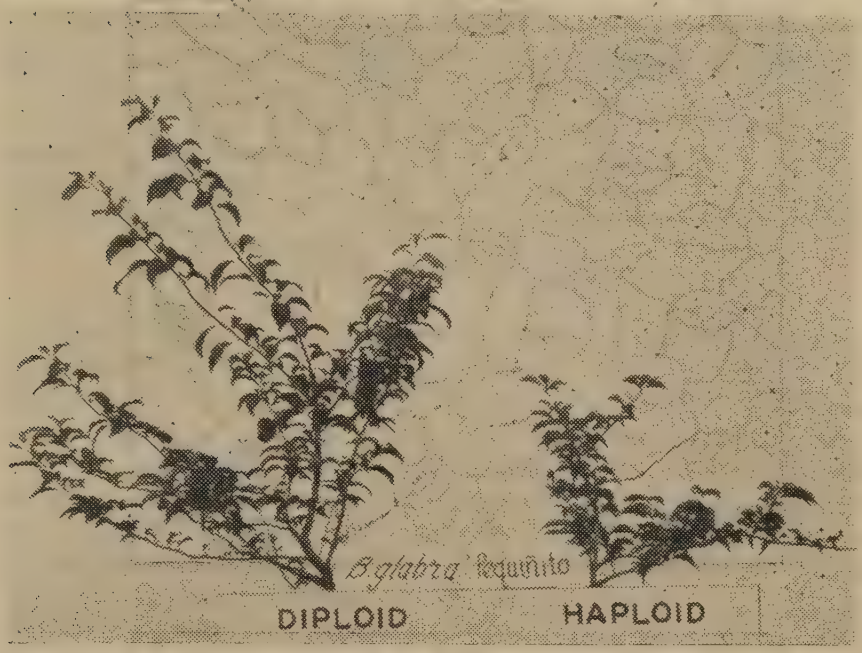


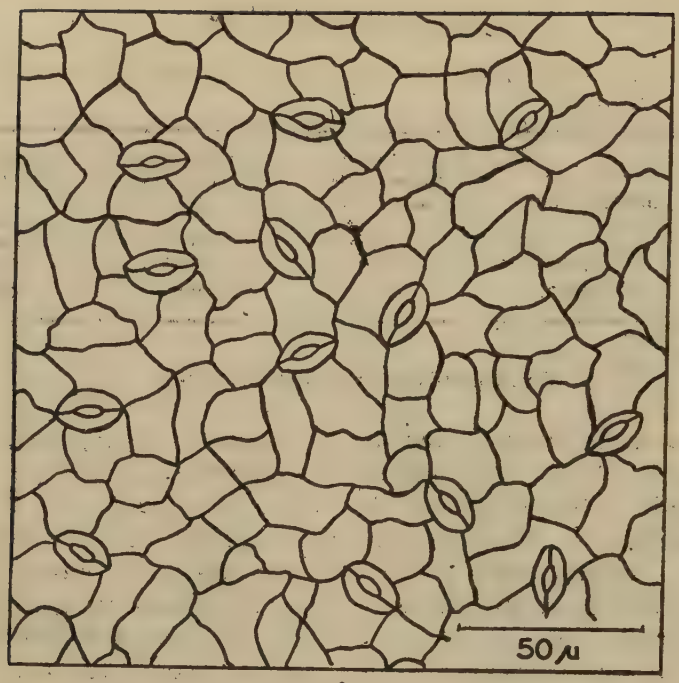
Fig. 1.—*A diploid and a hapliod* B. glabra *pequinito.*

a higher percentage of plump and well filled grains were found in the younger plants.

Attempts to cross at least 50 different cultivars using pollen from the haploid plant were not successful. When used as a female parent, however, the haploid gave some seeds. Of the 75 pollinations effected from different cultivars, 10 have resulted in a set of fruit, six of which germinated. All the seedlings raised from these were diploid, or approximately so, with the normal diploid properties. These were further verified by measurements of the meristematic cells and their nuclei in root-tips of haploid and diploid plants (table 1).

The length of the guard cells of the stomata of the haploid plants was also considerably shorter than that of similar cells in diploid plants, although the number of stomata per unit area[2] was the same in both haploid and diploid forms (fig. 2).

2/ Area refers to microscopic field.



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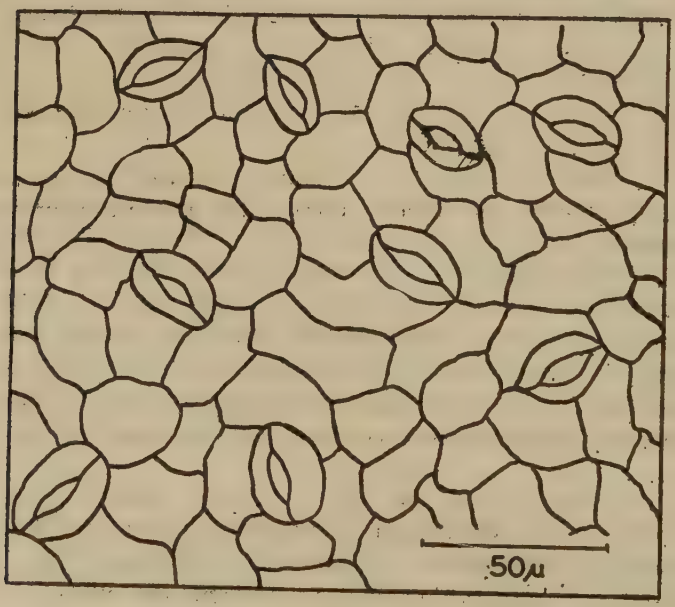

B

Fig. 2.—*Epidermis on lower surface of leaf in* Bougainvillea glabra *'Pequiñito' showing stomata: A—haploid, and B—diploid.*

TABLE 1.—*Comparative measurements of cells in haploid and diploid* B. glabra *'Pequiñito'*

PLANT	NO. OF OBSERVATIONS	Average Diameter of Nuclei of Meristematic Cells	Average Diameter of Meristematic Cells	Average Length of Guard Cells
		microns	*microns*	*microns*
Haploid	100	5.60	12.95	22.40
Diploid	100	10.15	18.25	30.80

CYTOLOGICAL OBSERVATIONS

Chromosomes were found to be synapsed, during prophase I, in the diploid, but no such pairing was observed in the haploid. At metaphase I, 17 bivalents were observed in the diploid. In the haploid at metaphase I, 17 small rounded or rod-shaped univalents were observed. The equatorial plates at metaphase in the haploids were not as regular as in the diploids, the chromosomes being somewhat more scattered (fig. 3). In some cells, however, pseudo-reduction division was exhibited; seven chromosomes were observed in one pole while the other 10 were seen in the opposite pole (fig. 4). No division of univalents as reported in wheat (Gaines and Aase, 1926), was noted, and no chromatin bridges were observed. Of interest was that occasional cells in the root-tips (somatic cell) of the haploid material possessed a diploid number of 34 chromosomes. This doubling may be ascribed, according to Weber (1933), to the failure of the chromosomes to separate at anaphase and to the inclusion of the diploid chromosome number during the formation of the restitution nucleus.

DISCUSSION

Haploidy in *Bougainvillea* apparently has not been previously recorded and the present paper presents the first case.

The appearance of diploid foliage and the return to complete fertility in two out of 38 cuttings propagated from haploid plants may be a case of chromosomal chimera due to the occurrence of diploid cells in the aerial portion of the meristematic tissue.

Blackeslee (1922), Chipman and Goodspeed (1927), Lindstrom (1929), Davis and Kulkarni (1930), Morinaga and Fukishima (1931,

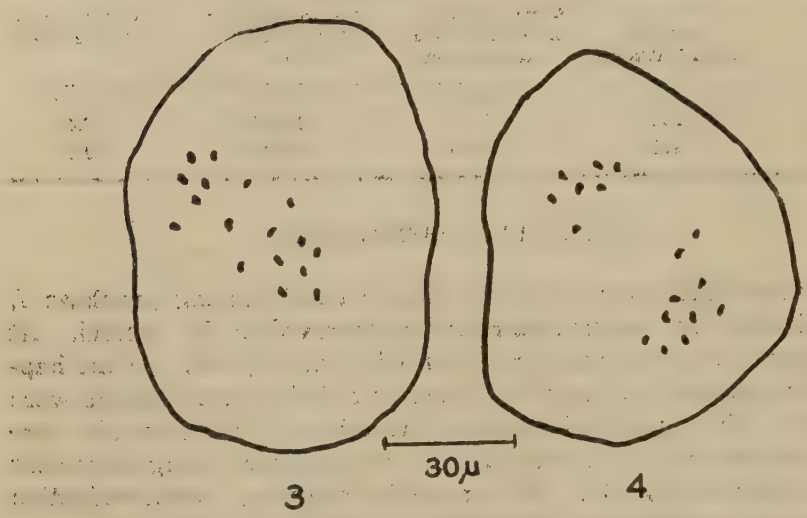

Fig. 3-4.—*Chromosomes in* bougainvillea: *fig.* 3, *PMC in haploid* bougainvillea *plant (random distribution of* 17 *univalents drawn from aceto-carmine preparation); fig.* 4, *PMC in haploid* bougainvillea *plant showing attempts at reduction division of* 17 *univalent chromosomes (also an aceto-carmine preparation).*

1933), Chisaki (1933), Okura (1933), and Johansen (1934) reported haploid forms in *Datura, Nicotiana, Lycopersicon, Oenothera, Oryza, Triticum, Portulaca,* and *Hordeum,* respectively, while Katayama (1934), Muntzing (1937), and Nordenskiold (1939) reported haploids in grasses following treatments with high and low temperature after X-ray treatment. Gerasimowa (1936) artificially obtained haploids in *Crepis tectorum* by pollinating X-radiated ovaries with untreated pollen, while Campos and Morgan, Jr. (1958) reported that a sperm functioned in the development of haploid pepper.

In the aforementioned species and parent plants recorded in literature, the haploids have been the resultant of causative agents like temperature changes and X-ray treatments applied to either the ovules or pollen.

It would be well to present a working hypothesis for the probable origin of the haploidy in *Bougainvillea* being reported. In a previous paper (Pancho, *et al.*, 1960), it was pointed out that triploidy and tetraploidy occur in *Bougainvillea* with 17 chromosomes as the basic number. This would indicate that polyploidy is its natural attribute. Moreover, it is a cross fertilizing species and under natural conditions of culture of various cultivars (numbering about 35), cross pollination could take place. Through the occurrence of parthenogenesis, the egg nucleus of a diploid cultivar may develop and give rise to an aberrant form, a haploid. The fusion of the pollen nucleus and egg nucleus does not take place, and one of the cells with a haploid nucleus organizes into a new haploid plant like the case under report. This aberrant plant will have characters derived only from one parent and will have only one set of chromosomes which remain unpaired under the meiotic cycle. It would seem, therefore, that the underlying cause of the haploid plant is parthenogenesis, a phenomenon quite common among flowering plants of polyploid type, but particularly under natural hybridization where the embryo is stimulated by the growth of the pollen tube which is nevertheless, unable to fertilize it.

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RESPONSE OF CITRUS TO FERTILIZATION[1]

B. C. FELIZARDO, N. L. GALVEZ, AND P. S. DAVIDE[2]

WITH THREE TEXT FIGURES

Observations on six-year-old szinkom trees grown on a Lipa clay loam with different fertilizer treatments indicated that lack of nitrogen limits plant growth and fruit production in the orchard. The unfertilized trees showed severe nitrogen starvation and were moribund at the end of two crop years. Highest yields were obtained from the plots that received the highest rate of nitrogen (1 kg. N per tree per year). High phosphorus application was also able to increase the yield when adequate nitrogen was added. In no instance did the trees respond to potassium.

Citrus is the fastest growing fruit industry in the Philippines today. In the last 10 years, areas devoted to it have greatly increased, and whereas formerly these trees were confined to backyard-sized lots, it is now common to find them occupying tens or hundreds of hectares. This was made possible primarily by yield-increasing fertilizers.

The effect of fertilizers on the chemical properties of citrus soils in Batangas was studied by Galvez *et al.* (1955). They found that the pH, calcium, and magnesium contents of soils receiving heavy applications of ammonium sulfate in a period of five to six years dropped appreciably while the amount of manganese increased by as much as ten times. It was predicted that, as a consequence of these changes in the soil, problems were likely to appear in these orchards if this fertilization practice is continued.

The above observations are important in the formulation of a sound and economical fertilizer program. But these are not enough. Even more important is information on the effect of fertilizers on the crop itself. Until now, there have not been any published data to show the extent of influence that fertilizers exert upon the growth and yield of the locally grown citrus varieties. It

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1/ Central Experiment Station Contribution No. 2805. Part of Research Project No. 671.

2/ The authors are grateful to: Atty. Z. Tanalega for the use of his orchard; Dr. L. E. Nelson for his technical advice in the plan and layout of the experiment; Messrs. S. N. Tilo, I. T. Corpuz, P. R. Vicente, and T. C. Cruz for their assistance in the various field operations; and Dr. J. G. Davide for his suggestions in the preparation of the manuscript.

is for this reason that an experiment was conducted by the Department of Soils from March, 1956 to March, 1958.

MATERIALS AND METHODS

A five-year-old szinkom grove of an unidentified rootstock was chosen. The soil is a gently sloping Lipa clay loam located in Dayap, Calauan, Laguna. Samples for characterization of the chemical properties were collected at the beginning of the experiment.

The trees were spaced 5 x 5 meters apart. As recalled by the overseer, each tree was given about 2 1/2 kilograms of a complete mixed fertilizer (12-24-12) the year before the experiment was conducted. Weeds were controlled by occasional crisscross harrowing of the orchard with a tractor-drawn cut-away disc.

The area was divided into four blocks. Eleven plots were randomly arranged within each block. Each plot consisted of five observational trees without guard rows between plots. The treatments are briefly described in table 1.

TABLE 1.—*Treatment and rate of fertilizers per application.*

TREATMENT	AMMONIUM SULFATE	SUPERPHOSPHATE	MURIATE OF POTASIUM
	gram per tree		
1. $N_0P_0K_0$	0	0	0
2. $N_1P_1K_1$	625	625	210
3. $N_2P_0K_0$	1250	0	0
4. $N_2P_0K_2$	1250	0	420
5. $N_2P_2K_0$	1250	1250	0
6. $N_2P_2K_2$	1250	1250	420
7. $N_2P_2K_2$ + lime	1250	1250	420
8. $N_2P_2K_4$	1250	1250	840
9. $N_2P_4K_2$	1250	2500	420
10. $N_4P_2K_2$	2500	1250	420
11. $N_2P_4K_4$	2500	2500	840

The fertilizers were applied evenly beneath the tree crown twice a year, after harvest and after fruit set. The lime in treatment 7 was applied only once at the start of the experiment at the rate of two kilograms per tree.

Yield data were obtained with the use of a "calibrated" 20-kilogram capacity field basket.

RESULTS AND DISCUSSION

Soil analyses. The results of the chemical analyses of the soil collected before the differential treatments were applied are shown in table 2. Since the fertilizer application was localized (under the

TABLE 2. — *Chemical properties of the soil at various depths.*

SOIL PROPERTY	BETWEEN TREES 0-6"	BETWEEN TREES 6-12"	UNDER TREES 0-6"	UNDER TREES 6-12"
		gram per tree		
PH	6.20	6.21	6.15	6.14
O.M. (%)	2.57	2.42	2.55	2.46
P (ppm)	90.77	88.14	96.04	102.34
K (m.e./100 gm. soil)	1.68	1.70	1.75	1.75
Ca „	17.16	16.54	16.41	16.49
Mg „	6.10	6.30	6.20	6.15
C.E.C. „	31.10	30.40	31.49	31.71

crown of the trees) the column "under trees" in the table should show the residual influence of the previous applications and the "between trees" column, the properties of the soil outside of the fertilized area. The table shows that the phosphorus content of the soil under the trees was higher than that between trees in the 0 to 6 and 6 to 12-inch depths. This indicates a residual accumulation of phosphorus resulting from the 2½-kilogram 12-24-12 fertilizer applied per tree during the past year. There was also a slight increase in the level of available potassium. Citrus soils in Batangas receiving annual applicatons of complete fertilizers [3] showed a similar trends.

The carry-over effect of phosphorus and potassium is a very important factor to consider in the overall fertilizer management program of an orchard. While a build-up of the amount of these elements is desired, an excessive supply should be avoided. Excess phosphorus was reported to induce a deficiency of copper (Bingham and Garber, 1960) and too high potassium depressed the absorption of the other bases particularly magnesium (Proebsting and Kasimatis, 1958). It is evident that the normal growth of crop plants required a balance of the nutrients in the soil including the trace elements. The objectives of fertilization especially in orchards,

3/ Unpublished data, Department of Soils.

therefore, should be not only to increase the available nutrient supply of the soil but also to maintain an optimum nutrient balance.

Since the application of 2 1/2 kilograms of 12-24-12 cause an accumulation of both phosphorus and potassium in the soil, these elements should be applied more sparingly or in smaller amounts in the following years than the more easily lost nitrogen. This would minimize not only the cost of fertilizer nutrients but also the adverse effects of their excess accumulation as well as the onset of an unbalanced nutrient supply in the soil.

In general, the pH, phosphorus, potassium, calcium, and magnesium contents of the soil are within the requirement of citrus plants. Some citrus soils in Florida were reported to contain 0.026 to 0.070 per cent nitrogen, 0.014 to 0.050 per cent phosphorus, trace to 0.016 potassium, and 0.022 to 0.086 per cent calcium (Delfs-Fritz, 1954).

Growth of trees and fruit development. Four months after the treatments were applied, foliage of the control trees gradually became yellower than the trees which were fertilized. They appeared pale and unthrifty after 12 months. Apparently, they suffered from nitrogen deficiency. Trees in the low nitrogen plots ($N_1P_1K_1$) showed slight yellowing.

The trees in the treatments with the highest nitrogen (N_4 series) showed the thickest and greenest foliage. A deep green color of the fruits also persisted up to harvest time. Unfortunately, this effect reduces the marketability of the fruits because consumers prefer to buy those that appear mellow and ripe. Good fruiting with regard to size, juice, and fiber was obtained in South Africa with the addition of nitrogen alone (Delfs-Fritz, 1954).

Yield; Response to different elements. The trees responded excellently to nitrogen but poorly to phosphorus, potassium, and calcium especially in the second year harvest (fig. 1). All the plots which received nitrogen alone or in combination with phosphorus or potassium yielded significantly more than the control.

Similar results were obtained on corn by Tilo (1957) and on sugar cane by Garrucho (1957) on the same soil series. The same trend of response is true with rice (Calma, *et al.*, 1952) indicating that nitrogen is the fertilizer element affecting crop production in a Lipa soil series.

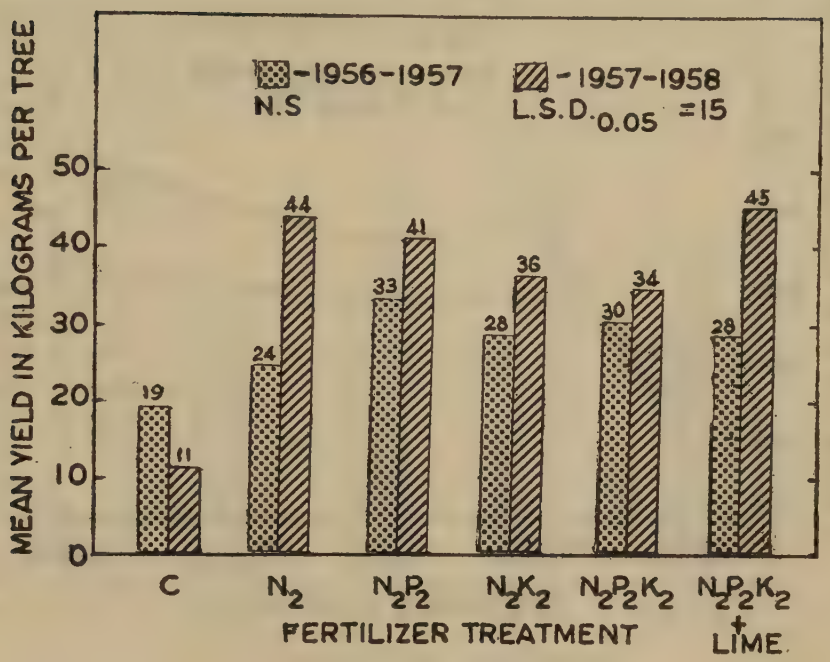

Fig. 1.—*The effect of different fertilizers and lime on the yield of szinkom.*

The non-response of the six-year-old szinkom trees to both phosphorus and potassium should not mean that these elements may be omitted completely in the fertilizer program of the orchard. High yields as a result of nitrogen fertilization would impoverish the soil sooner so that even in fairly productive soils, complete fertilizers are recommended to avoid a one-sided removal of the essential elements.

Further, it can be observed in figure 1 that a yield of 44 kilograms per tree may be expected of a six-year-old szinkom receiving 2 1/2 to 3 kilograms of ammonium sulfate.

Response to increasing rate of 1:1:1 *fertilizer.* The yield of szinkom markedly increased as the rate of 1:1:1 fertilizer applied was increased (fig. 2, 1957-58 yield). The increase in yield was

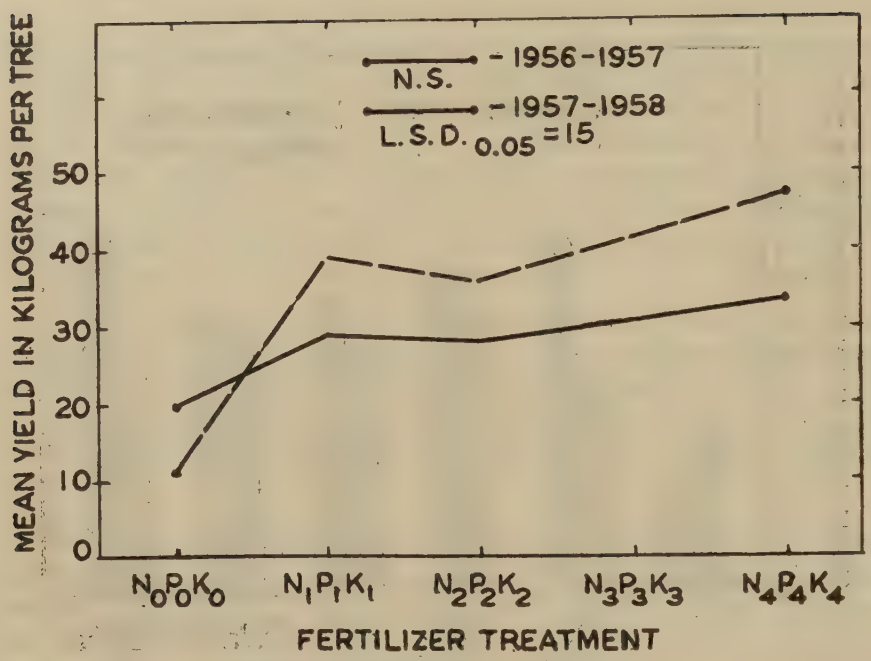

Fig. 2.—*The effect of increasing the rate of* 1:1:1 *fertilizer on the yield of szinkom.*

perhaps due to the increased rate of nitrogen application. It was pointed out earlier that the trees did not respond to both phosphorus and potassium.

The highest yield per tree was obtained from the plot which received the highest application of nitrogen. It should also be noted that the response of the trees is highly significant even at the first increment of nitrogen added. This indicates that for high fruit production, nitrogen fertilization should be practised in this orchard.

Response to different rate combinations of N, P, and K. While the general response discussed earlier was attributed to nitrogen, data presented in figure 3 (1957-58) further show that there is an interaction of effects between nitrogen and phosphorus. The in-

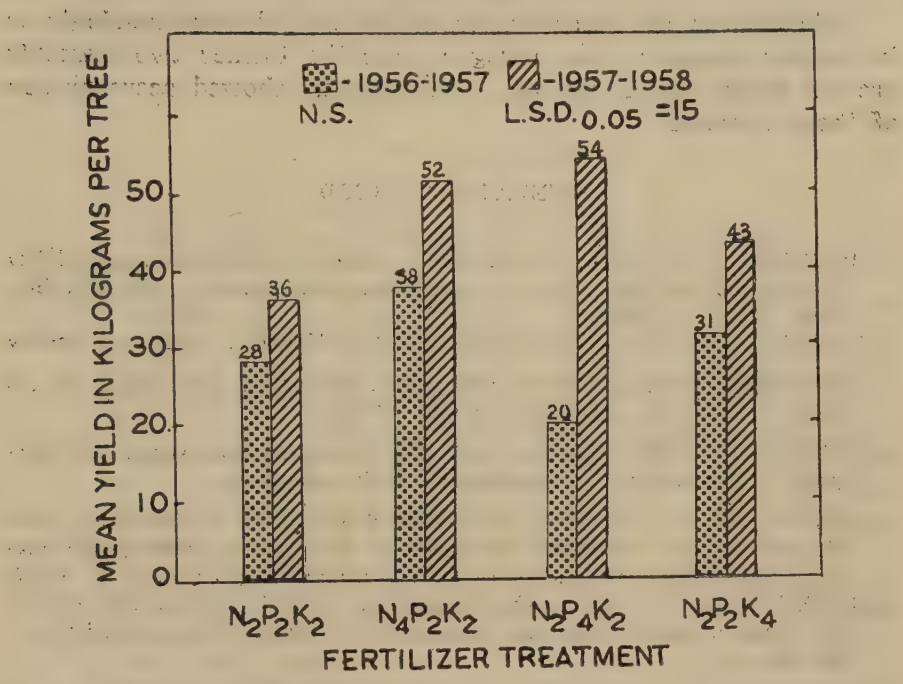

Fig. 3.—*The effect of different rate combinations of nitrogen, phosphorus and potasium on the yield of szinkom.*

crease in yield from N_2 to N_4 at the same P_2 and K_2 levels was significant. However, there was no difference between N_4P_2 and N_2P_4 at the potassium level. These results show that increasing the rate of nitrogen application effect yield increase when there is an adequate supply of phosphorus and *vice versa*. The effect of potassium is not evident from the data. The potassium content of the soil may be considered adequate.

SUMMARY AND CONCLUSIONS

Five-year-old szinkom trees grown on Lipa clay loam were fertilized differently for two years. Growth and yield observations show that lack of nitrogen limits fruit production in the orchard. Two-and-a-half to three kilograms may be the amount of ammonium sulfate optimum for the trees. At this rate of application,

about 44 kilograms may be the expected yield per tree.

Phosphorus and potassium should be applied more sparingly or in smaller amounts than nitrogen since the former two elements are not easily lost in the soil. Soil analysis showed accumulation of these elements.

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PERFORMANCE OF SYNTHETIC POPCORN VARIETIES DEVELOPED FROM STANDARD U. S. INBRED LINES 1/

PABLO C. JAVIER AND JOSE A. MALABUYOC 2/

WITH TWO TEXT FIGURES

White- and yellow-endosperm popcorn synthetics made up of standard popcorn inbred lines from the United States were studied mainly to determine their possible utilization as sources of germplasm for high popping expansion and as probable replacements for local popcorn varieties. Among the nine white-endosperm synthetics, Synthetic White Pop Nos. 9, 3, and 2 had the highest popping expansions with values of 26.75, 24.58, and 22.51, respectively, as against that of the check, Laguna White Pop, which was 18.70. Synthetic White Pop No. 2, though lowest among the three in popping expansion, is also desirable as a source of good germplasm for high popping expansion for it also had a higher yield, and better relative resistance to stalk breaking and Helminthosporium leaf spot than the two other synthetics. Its only big liability is the poor husk coverage on its ears.

Among the 19 yellow-endosperm synthetics, Synthetic Yellow Pop Nos. 12, 3, 8, 7, 2, and 13 (in their decreasing order of expansion) gave both high popping expansion and relatively good yields. Synthetic Yellow Pop Nos. 12 and 13 gave popping expansions of 27.45 and 20.32, respectively, as against that of the check, Davao Yellow Pop, which was 14.32, in the dry season. If recommendations were to be made, these six synthetics would probably be selected as follows: 3, 12, 8, 7, 2, and 13 in the order of their predicted usefulness as a source of germplasm for high popping expansion, fairly good yields, and relative resistance to stalk breaking.

For limited growing, the following are suggested as possible replacements for local popcorn varieties in the meantime that hybrid seed is not yet available: Synthetic White Pop Nos. 2 and 9 for the white-endosperm popcorn and Synthetic Yellow Pop Nos. 3, 12, and 8 for the yellow-endosperm popcorn.

Double-cross hybrid corn is profitable to grow in places where it is adapted, particularly on rich soil. In marginal areas, however,

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1/ Central Experiment Station Contribution No. 2806.

2/ The authors are grateful to: Messrs. I. S. Santos and F. A. Aquilizan for their helpful suggestions during the conduct of the experiment and in the preparation of the manuscript; Miss D. A. Ramirez for the use of her Worthmore home electric popper, and the Rockefeller Foundation for donating the "official" weight-volume tester (also used in this experiment) to the Plant Breeding Division.

whatever increase in yield hybrid corn gives may not compensate for the investment on seeds. In such places, the use of superior synthetics which yield higher than any adapted open-pollinated variety may prove more practical and useful. Its greater variability would permit wider adaptability to various conditions where it is planted. Furthermore, farmers would not have to buy seeds everytime they plant as seeds selected from the commercial crop can be used for planting.

Brunson (1937) contended that "the technique followed in popcorn breeding should be the same as that followed in field corn." In the evaluation of popcorn, high yielding ability is desirable but eating quality plays a more important role since this type of corn is primarily used as food. It is expected that in the near future, both growers and consumers would demand for popcorn that have high popping expansion and tenderness. Growers would, in addition, desire such qualities as high yield and good standing ability.

Hayes (1926) compared the yields of five synthetic varieties of corn with their parents. Results showed that their yields ranged from a decrease of 11.7 per cent to an increase of 16.6 per cent.

Kiesselbach, as cited by Lonnquist (1949), concluded from his work on yields of first and second generations of 8-and16-line synthetics that while some of the synthetics were as productive as the standard varieties, not one could be considered as superior.

Sprague and Jenkings (1943), working on five synthetics, found that their yield was just about the same as that of adapted open-pollinated varieties.

Hayes, Rinke, and Tsiang (1944) reported a synthetic which had a yield equal to that of Minhybrid 403, a double cross hybrid, and which is superior to an open-pollinated variety used as check.

Santos *et al.* (1959) reported two synthetics which have significantly outyielded the College Yellow Flint variety (used as check) in one of their tests. The yield of the two synthetics was as high as that of the other check, the double cross Philippine Hybrid No. 1d, (Ph9 x Phll) (Ph13 x Ph17).

Lonnquist (1949) stated that satisfactory yielding synthetics which stand well, if developed, could be of great value in places where the cost of hybrid seed is high relative to the value of the

expected harvest. He further stated that the greater variability of a synthetic should permit its adjustments to a more variable condition in the area where it is planted. On the other hand, Sprague and Jenkins (1943) suggested that "the greatest usefulness of synthetics may be as reservoir of desirable gene combinations".

This work was conducted in the Central Experiment Station and in the laboratory of the Plant Breeding Division, U.P. College of Agriculture, from May, 1959 to March, 1960. It aimed to (1) test the popping expansion and yielding ability of the different white- and yellow-endosperm synthetic popcorn varieties developed in the U.P. College of Agriculture, (2) determine whether or not any of these synthetics could reasonably be utilized as sources of superior germplasm for popcorn inbred lines, and (3) find out if one or more of these synthetics can be recommended as replacements for local popcorn varieties.

MATERIALS AND METHODS

The following varieties were used in the experiment:

1. Open-pollinated varieties:

   Laguna White Pop

   Davao Yellow Pop

2. White-endosperm synthetic varieties:

Designation	*No. of lines involved*	*Pedigree*
Synthetic White Pop 1	8	[(P22 x P303) (P31 x P32)]3*
Synthetic White Pop 2	6	(P32 x P303)
Synthetic White Pop 3	4	(Exp. 3323 x P20)
Synthetic White Pop 4	5	(Exp. 3323 x P32)
Synthetic White Pop 5	8	[(Exp. 3323 x P20) (P202 x P213)]*
Synthetic White Pop 6	9	[(Exp. 3323 x P20) (P202 x P303)]*
Synthetic White Pop 7	7	[(Exp. 3323 x P20) (P202 x P406)]*
Synthetic White Pop 8	6	[(Exp. 3323 x P32) (P20 x P22)]*
Synthetic White Pop 9	9	[(Exp. 3323 x P213) (P202 x P303)]*

3. Yellow-endosperm synthetic varieties:

3/* means sibbing or brother and sister mating.

Designation	*No. of lines involved*	*Pedigree*
Synthetic Yellow Pop 1	6	[(P22 x P406) (P31 x P32)]
Synthetic Yellow Pop 2	7	[(P22 x P406) (P31 x P202)]
Synthetic Yellow Pop 3	7	[(22 x P406) (P213 x P31)]
Synthetic Yellow Pop 4	6	[(P22 x P406) (Exp. 3323 x P213)]
Synthetic Yellow Pop 5	6	[(P31 x P32) (P20 x P202)]
Synthetic Yellow Pop 6	8	[(P31 x P32) (P202 x P406)]
Synthetic Yellow Pop 7	9	[(P31 x P32) (P406 x P303)]
Synthetic Yellow Pop 8	7	[(P202 x P213) (P20 x P32)]
Synthetic Yellow Pop 9	8	[(P202 x P213) (P22 x P32)]
Synthetc Yellow Pop 10	8	[(P202 x P213) (P31 x P32)]
Synthetic Yellow Pop 11	7	[(P202 x P406) (P22 x P31)]
Synthetic Yellow Pop 12	8	[(P202 x P406) (P213 x P31)]
Synthetic Yellow Pop 13	7	[(P202 x P406) (Exp. 3332 x P213)]
Synthetic Yellow Pop 14	7	[(P213 x P406) (P20 x P202)]
Synthetic Yellow Pop 15	7	[(P213 x P406) (P31 x P32)]
Synthetic Yellow Pop 16	8	[(P213 x P406) (P31 x P202)]
Synthetic Yellow Pop 17	6	[(P213 x P406) (Exp. 3323 x P20)]
Synthetic Yellow Pop 18	6	[(Exp. 3323 x P32) (P20 x P31)]
Synthetic Yellow Pop 19	8	[(Exp. 3323 x P32) (P202 x P213)]

The synthetic varieties were produced from crosses between introduced American popcorn hybrids. The F1 generation crosses were sib-pollinated and the results were advanced-generation hybrids which could be considered as synthetic varieties. The parental hybrids of the multiple crosses were obtained through Dr. A. M. Brunson of Purdue University, Lafayette, Indiana, U.S.A. The pedigree of the hybrids may be summarized as follows:

Hybrid	*Pedigree* [4]
P20	(Sg18 x Sg30)

4/ P—Purdue
Exp.—Experimental Purdue hybrid
Sg—Supergold
I—Iowa
SA—South America
Al—Alabama

P22	(Sg16 x Sg18)
P31	(Sg16 x Sg18) x SA24
P32	(Sg18 x Sg30) x SA24
P202	(A1-6A x SA1490)
P213	(Sg18 x Sg1533) x I28
P303	(I27 x I29) x SA4533
P406	(Sg18 x Sg1533) x P67-2L
Exp. 3323	(Sg18 x Sg1533) x P67-2K

All these hybrids except P303 have yellow endosperm.

The white-endosperm synthetic varieties were developed from segregates of the advanced generation of yellow hybrid x white hybrid and from accidental outcrosses of the yellow multiple hybrids with the Laguna White Pop, a local open-pollinated white-endosperm popcorn variety. The former group had four synthetics involving P303 in their pedigrees.

There were two groups in the performance test. Group I was composed of the white-endosperm synthetics and Group II, of the yellow-endosperm synthetic varieties. Laguna White Pop and Davao Yellow Pop were used as checks for the synthetic white popcorn and synthetic yellow popcorn varieties, respectively.

The performance trial was conducted during the wet and dry seasons. The wet-season crop was planted in May, 1959 and the dry-season crop in October of the same year.

The simple randomized block design with four replications was used in both groups during the two seasons of testing. Each plot consisted of two rows, five meters long and spaced one meter apart. There were 10 hills spaced one-half meter in each row. Five seeds were planted per hill and these were thinned to three plants after three weeks. Just before planting, the plots were uniformly fertilized with ammonium phosphate (18-20-0) at the rate of 250 kilograms per hectare. Ammonium sulfate (20-0-0) at the rate of 200 kilograms per hectare was side dressed one month after planting. The experimental field was cultivated thoroughly

and weeded occasionally. Insect-pest and disease injuries were minimized by spraying the plants twice with an insecticide-fungicide combination of Gesarol E25 applied at the rate of 18 ml. and Parzate given at the rate of nine grams per gallon of water. The first spraying was done about three weeks after emergence and the second, just before flowering. Rat traps and poison baits were put around the experimental field and along the alleys to prevent serious rat damage.

The silking date of each plot was taken at the time when 50 per cent of the plants in the plot had silked. The days to silking of each plot was determined by taking the number of days from 50 per cent emergence to 50 per cent silking.

Average plant and ear heights in centimeter were measured after flowering. Plant height was measured from the ground level to the tip of the tassel and the ear height, from the ground level to the node where the highest ear is attached.

Data on stand of the crop and on root- and stalk-lodgings were taken just before harvesting. A plant is said to be root-lodged when it leans 45 degrees or more from its vertical position. This type of lodging is usually due to a weak root system. Stalk lodging or breaking is brought about by the actual breaking of stalks between the roots and the ear node. Breaking may occur anytime, but it usually happens after the corn has matured and continues until harvest. A plant would not ordinarily be counted as both root-lodged and stalk-lodged so that the two categories are mutually exclusive. Lodging percentages were based on the actual number of plants per plot at the time lodging data were taken.

An arbitrary rating for husk coverage was made during the dry season. A rating of good was given to those ears with tightly fitted husks which extended well beyond the tip of the ears. A rating of poor was given when the ears extended beyond the husks and these husks were so frayed that the ears were open to the attack of insect-pests.

Ears from each plot were harvested, dried, and shelled separately. Moisture content just after shelling was determined using the Steinlite electronic moisture tester. Grain yield was calculated in cavans per hectare at 15 per cent moisture. The drying was done

in a forced hot-air (HABCO) drier. Before shelling, the average number of kernel rows and size of ears (length and diameter in centimeter), and the rating for flintiness of the grain were recorded. The rating used for flintiness was 1 for very flinty; 2, flinty; and 3, starchy crowns.

The popping expansion of the different varieties was also evaluated. Popping expansion is the ratio of the volume of the corn after popping to the volume before popping. This characteristic depends mainly on three conditions—the inherent structure of the kernels, their moisture content, and the proper application of heat. Other important factors include the kind of popper and the seasoning, the temperature of the popper, and the size and shape of the container (Brunson and Richardson, 1958).

The popping ability of each variety was tested during the wet and dry seasons. Three samples were tested for each variety. The moisture contents of the samples were carefully determined before popping. Dungan *et al.* (1953) stated that the moisture content considered by many authorities as best for popping expansion is 13.5 per cent. In this study therefore, only those samples having a moisture content of 13.50 -|- 0.11 per cent were popped. Entries with higher moisture contents were dried further and those with lower moisture content were allowed to absorb moisture in a damp, convered container until they reached the optimum moisture content for best popping expansion.

In the absence of a better apparatus in the wet-season test, the Worthmore home electric popper consisting of an electric heater and an aluminum kettle was used (fig. 1). The popper is not provided with an agitator so that manual shaking has to be practiced occassionally while popping. Uniform amounts of vegetable cooking oil (3 ml.) and raw corn (25 ml.) were placed in the popper each time. The raw corn was allowed to pop completely. Due to the absence of any accurate instrument, it was hard to control or standardize the popping temperature.

In addition to popping expansion, an attempt to determine the popping percentage was also made with the formula:

$$\text{per cent popping} = \frac{\text{No. of popped kernels}}{\text{No. of kernels in sample}} \times 100$$

The "official" weight-volume tester (fig. 2) adopted by the

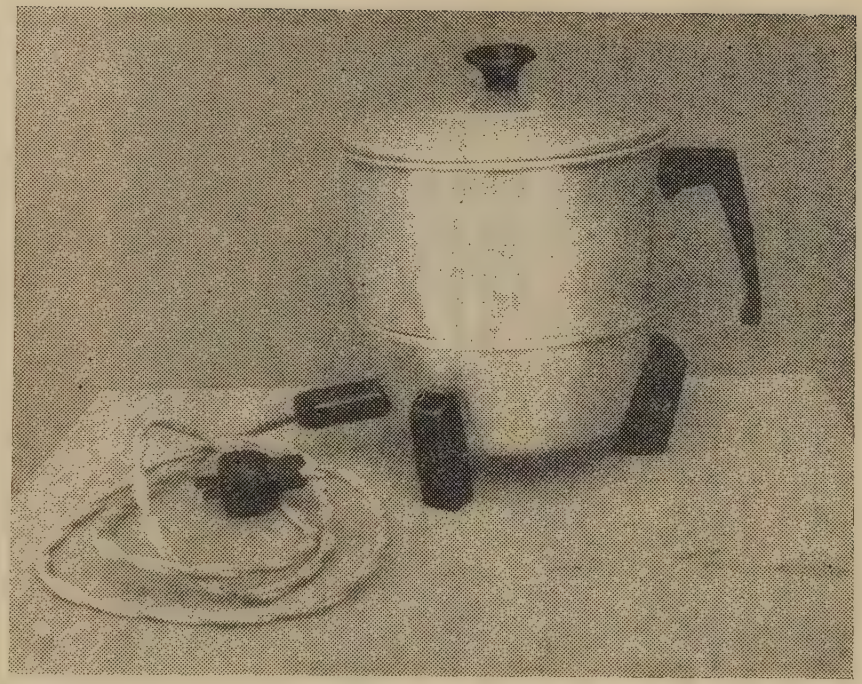

Fig. 1.—*Worthmore home electric popper.* (Photographed by the Photographic Division)

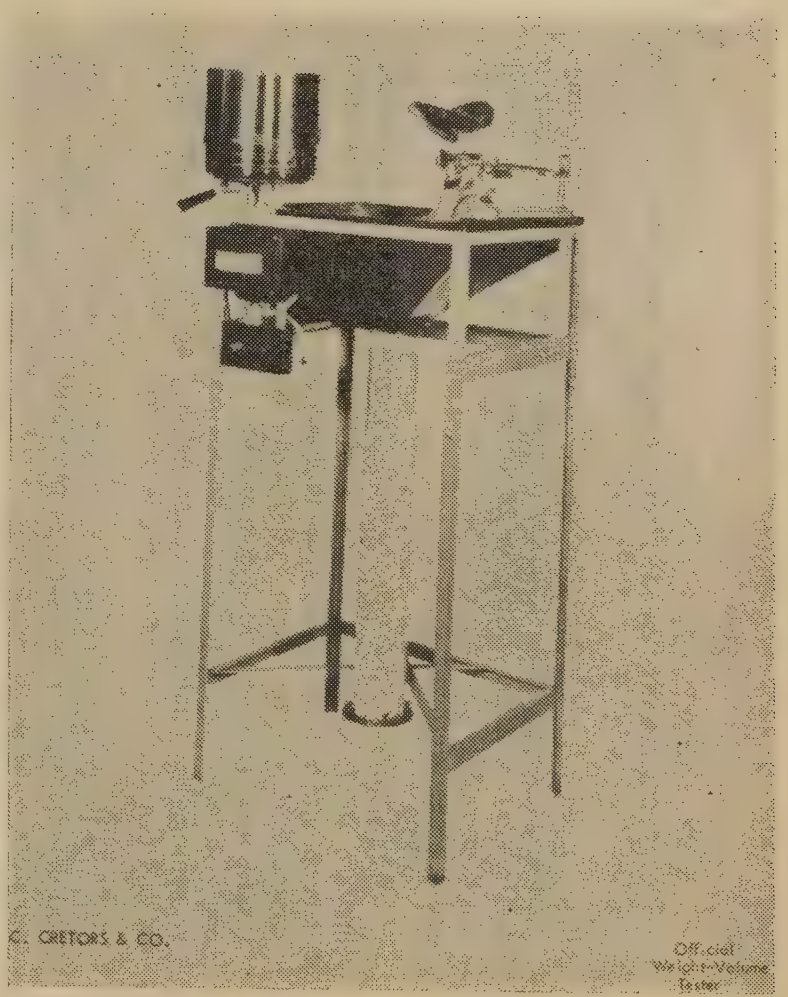

Fig. 2.—*"Official" popcorn weight-volume tester.* (Photograph courtesy of C. Cretors & Co., Tenn., U.S.A.)

American Popcorn Processors Association was put to use in determining the popping expansion of the dry-season crop. This popper has a thermostatically-controlled heating unit, an agitator, and a calibrated cylinder at the bottom of the chute for measuring the popped volume in cubic inches per pound of raw corn. Each load for popping was composed of 2 fluid ounces of vegetable cooking oil and 150 grams of raw corn. A uniform popping time of 2 1/2 minutes was used for each load. Before popping, each of the 150-gram samples of unpopped kernels was measured in milliliters. The popped volume reading on the cylinder was converted into milliliters. The volumetric readings were then equated to obtain the popping expansion.

RESULTS AND DISCUSSION

For convenience, results will be presented by groups. Data on white-endosperm popcorn will be shown under Group I, and on yellow-endosperm popcorn under Group II.

While the emphasis will be on tenderness which, according to Brunson and Richardson (1958), is reflected by poping expansion, grain yields and relative resistance to stalk-breaking will also be considered in the selection of possible sources of germplasm from which to start the selection and development of popcorn inbred lines which can impart high poping expansion for their crosses. Brunson (1955) pointed out that the ability to pop is controlled by many genes.

The selection will not necessarily be for synthetics with very high yields but for those with fairly good yields provided these are superior in popping expansion. Popcorn, both in the United States (Brunson, 1955) and in the Philippines, has generally been observed to be susceptible to stalk-breaking in contrast with comparable materials of the dent or flint types.

The separate analyses of the yield data for each season show very high coefficients of variability. For Group I, they were 33.0 per cent and 19.4 per cent for the wet and dry seasons, respectively; for Group II, they were 26.0 per cent and 20.0 per cent for the wet and dry seasons, respectively. Variability in yields introduced by heavy rat damage on some plots certainly contributed greatly to these very high coefficients of variability. In spite of these high

coefficents, however, the grain yield data did not seem worthless and, in fact, seemed sufficiently accurate in relation to the importance of the role to be played by grain yield in the selection of one or a few good-popping synthetics. The selected synthetics are expected to provide a broad gene base from which to start selection of good-popping inbred lines that may be better in yield and adaptability than the introduced original lines which were used in making the synthetics.

Although selection for high popping expansion will be based on popping-expansion data obtained from the 1959-60 dry season plantings, popping-expansion and popping-percentage data from the 1959 wet season crop are also presented in the pertinent tables for whatever they are worth. Popping-expansion data from the 1959-60 dry season plantings are definitely much more reliable because these were obtained with the use of an "official" weight-volume tester. The high degree of repeatability of popping expansion as obtained with the use of the "official" popper should convince anybody of the accuracy of such data. Note that for popping expansion of both groups, the corresponding H. S. D.'s (honest significant difference) were higher in the wet season than in the dry season in spite of the higher values obtained in the latter. This, of course, reflects the higher accuracy of the "official" popper used in the dry season as compared to the "crude" or ordinary popper used in the wet season.

Moisture content of the popcorn samples were popped within the recommended range of 11 to 15 per cent (Brunson and Richardson, 1958) and very close to the optimum 13.5 per cent.

Group I

Grain yield and popping quality. Table 1 summarizes the yield and popping data for the two seasons of tests. In addition to the H.S.D.'s for the means based on data for two seasons, the H.S.D.'s for each season are also given.

The combined yield data for both seasons were analyzed. The mean squares for season were significant at the 0.05 level; those for entries and entry x season interaction were highly significant. The highly significant entry x season interaction was not due to spectacular reversals of relative yields where one entry performed very well in the wet season and very poorly in the dry season, and another variety performed the other way. Rather it was due mainly

TABLE 1.—*Summary of grain yield and popping expansion of 9 white endosperm popcorn synthetics and Laguna White Pop in the* 1959 *wet* 1959-60 *dry season.*

ENTRY	YIELD			POPPING EXPANSION		PER CENT POPPING
	1959 Wet	1959-60 Dry	MEAN	1959 Wet	1959-60 Dry	1959 Wet
			cav./ha.			
Syn. White Pop 1	51.3	27.9	39.6	9.33	14.40	86.7
Syn. White Pop 2	35.1	33.0	34.1	18.40	22.51	98.0
Syn. White Pop 3	21.8	20.2	21.0	13.86	24.58	95.7
Syn. White Pop 4	20.7	12.2	16.5	14.67	15.31	94.3
Syn. White Pop 5	26.7	17.5	22.1	16.13	20.33	97.3
Syn. White Pop 6	43.8	25.2	34.5	11.17	20.04	98.0
Syn. White Pop 7	36.3	20.6	28.5	15.33	20.22	97.7
Syn. White Pop 8	17.7	19.9	18.8	15.27	20.37	93.0
Syn. White Pop 9	25.4	16.8	21.1	15.20	26.75	99.0
Laguna White Pop	26.0	31.2	28.6	11.47	18.70	88.7
H. S. D.						
0.05	24.6	10.6	12.8	2.98	1.36	6.1
0.01	29.4	12.7	15.1	3.64	1.67	7.4

to the spectacular yields of certain entries like Syn. White Pop 1, Syn. White Pop 6, and Syn. White Pop 7 in the wet season and to their relatively mediocre yields in the dry season. Only Syn. White Pop 8 which had an unusually low yield in replication III, and Laguna White Pop had wet season yields that were lower, and only slightly at that, than dry-season yields. Considering the high C.V.'s in each of the two seasons, it would be safer to select for high yield on the basis of the mean performance for both seasons.

Based on data for two seasons, none of the synthetics significantly outyielded the check, Laguna White Pop. The same situation was obtained during the dry-season test. Syn. White Pop 1, which gave the highest mean yield for the two seasons, was the only synthetic that significantly outyielded the check during the wet-season test. Based on the two-season mean, the higher yielding synthetics were Syn. White Pop Nos. 1, 6, and 2.

The mean square for entries in the separate analyses of popping expansion data in each of the two seasons were highly significant; likewise, that in the analysis of popping percentage was also highly significant.

Synthetics which gave high popping expansion during the dry season test were Syn. White Pops 9, 3, and 2. The popping expansions of these synthetics were all significantly better than that of the check at the 0.01 level. Other synthetics gave significantly

better popping expansion than the check, but the numerically small differences can be of only limited practical value to growers and consumers.

Plant characters. Data on number of days from germination to half-silking, plant and ear heights, and root- and stalk-lodgings are summarized in table 2. None of the synthetics exceeded the

TABLE 2.—*Days to silking, height and lodging of 9 white-endosperm popcorn synthetics and Laguna White Pop during the* 1959 *wet and the* 1959-60 *dry seasons.*

ENTRY	DAYS TO SILKING		PLANT HEIGHT		EAR HEIGHT		ROOT LODGING	STALK LODGING
	Wet	Dry	Wet	Dry	Wet	Dry		
			cm.	*cm.*	*cm.*	*cm.*	*per cent*	*per cent*
Syn. White Pop 1	43	49	204	188	75	75	24.5	6.7
Syn. White Pop 2	44	48	197	193	65	62	22.0	4.1
Syn. White Pop 3	42	46	172	182	62	55	39.5	23.0
Syn. White Pop 4	42	49	179	174	72	64	49.6	21.3
Syn. White Pop 5	42	48	192	176	61	64	32.1	15.4
Syn. White Pop 6	42	49	195	191	79	62	18.7	5.1
Sny. White Pop 7	42	47	202	184	76	72	29.8	17.8
Syn. White Pop 8	41	46	170	169	58	58	17.0	16.1
Syn. White Pop 9	40	47	172	180	59	68	24.4	2.8
Laguna White Pop	45	49	218	196	102	83	35.2	6.7

check in maturity, plant height, and ear height in both seasons. Syn. White Pops 3 and 4 had relatively high percentages of root and stalk lodgings. Laguna White Pop also had a relatively high percentage of root lodging but a relatively low percentage of stalk lodging. Syn. White Pops 3, 4, 5, 7, and 8, which all involve outcrossing to Laguna White Pop, had a relatively high percentage of stalk breaking than the rest. Syn. White Pops 9, 2, and 6 show indications that they could be possible sources of germplasm for resistance to stalk-breaking.

Ear and Kernel characters. Table 3 summarizes the data on ear and kernel characters. Syn. White Pop 1 and Laguna White Pop had kernels which were somewhat less flinty than the rest of the entries. This probably accounts for their low popping expansion. Syn. White Pop 8 gave a shelling percentage a great deal below the usual 80 per cent for flint corn. Syn. White Pop 2 and 8 had poorly covered ears and Syn. White Pop 1 had the biggest ears.

Pests and diseases. Syn. White Pop 1 suffered severely from the Helminthosporium leaf spot, *Helminthosporium maydis* Nisikado and Miyake, in the wet season. In the same season, rust, *Puccinia polysora* Underwd., caused much injury to Syn. White

TABLE 3.—*Summmary of ear and kernel characters of 9 white-endosperm popcorns, synthetic and Laguna White Pop, during the 1959 wet and 1959-60 dry seasons*

ENTRY	EAR CHARACTERS					FLINTINESS a/
	Length	Diameter	Kernel Rows	Per Cent Shelling	Ear Coverage	
	cm.			*cm.*		
Syn. White Pop 1	16.0	3.4	14	79.8	Good	3
Syn. White Pop 2	16.0	2.8	14-16	78.8	Poor	2
Syn. White Pop 3	12.8	2.7	14-16	78.7	Fair	2
Syn. White Pop 4	13.5	2.8	14	74.8	Fair	2
Syn. White Pop 5	14.4	2.7	14	76.9	Fair	2
Syn. White Pop 6	14.0	3.0	16	28.6	Fair	2
Syn. White Pop 7	14.3	2.8	14-16	79.0	Poor	2
Syn. White Pop 8	13.1	2.9	14-16	69.8	Fair	2
Syn. White Pop 9	15.1	3.0	16-18	79.8	Fair	2
Laguna White Pop	13.9	3.3	14-16	77.5	Fair	3

a/ 1 — Very flinty
2 — Flinty
3 — Starchy crowns

Pop 6 and only moderate injury to the rest of the entries. The percentages of susceptibility to stalk rot, *Gibberella moniliformis* (Sheldon) Wineland, were all low: Only Syn. White Pop 7 exhibited a percentage of as much as 7. Syn. White Pop 4 appeared more susceptible (15.3 per cent) to downy mildew, *Sclerospora philippinensis* Weston, than the rest of the entries. Syn. White Pops 2 and 5 were not injured by the stalk borer and earworm while some of the rest suffered at most only slight injuries. The Rhizoctonia disease, *Rhizoctonia solani* Kuhn., caused slight to moderate injuries to all entries during the wet season, and only slght injuries during the dry season.

Group II

Grain yield and popping quality. The yield and popping data for the two seasons of tests are given in table 4. The analysis of variance for the combined data of the two seasons shows that the mean squares for season and for entries, respectively, were highly significant. Unlike in Group I, there was no entry season interaction.

Davao Yellow Pop was the highest yielder in both seasons. Based on the means for two seasons, only two yellow synthetics, No. 4 and No. 17, were not significantly outyielded by the varietal check, Davao Yellow Pop.

Syn. Yellow Pop Nos. 12, 3, 8, 6, 7, 2, and 13, (in the decreasing order of popping expansion) all had high popping expansions which

TABLE 4.—*Summary of grain yield and popping expansion of 19 yellow-endosperm popcorn synthetics and Davao Yellow Pop in the 1959 wet and 1959-60 dry seasons*

ENTRY	YIELD			POPPING EXPANSION		PER CENT POPPING
	1959 Wet	1959-60 Dry	Mean	1959 Wet	1959-60 Dry	1959 Wet
	cav./ha.					
Syn. Yellow Pop 1	32.0	15.7	23.8	14.53	18.48	99.3
Syn. Yellow Pop 2	38.6	19.2	28.8	16.67	20.91	99.7
Syn. Yellow Pop 3	43.0	19.3	31.2	16.66	22.09	98.3
Syn. Yellow Pop 4	43.6	31.0	37.3	16.40	14.28	98.7
Syn. Yellow Pop 5	25.3	19.8	22.6	18.27	18.90	93.3
Syn. Yellow Pop 6	27.9	22.1	25.0	18.00	21.50	97.0
Syn. Yellow Pop 7	37.8	22.1	30.0	14.00	21.08	95.3
Syn. Yellow Pop 8	33.2	21.9	27.6	15.87	21.69	99.3
Syn. Yellow Pop 9	40.0	25.8	32.9	15.60	18.16	97.0
Syn. Yellow Pop 10	33.8	23.9	28.8	12.27	19.22	96.7
Syn. Yellow Pop 11	44.1	17.1	30.6	15.73	19.74	97.7
Syn. Yellow Pop 12	31.6	26.4	29.0	19.73	27.45	99.7
Syn. Yellow Pop 13	38.2	26.3	32.3	17.00	20.32	93.7
Syn. Yellow Pop 14	36.7	26.9	31.8	13.87	16.50	95.0
Syn. Yellow Pop 15	33.8	19.2	26.4	15.73	18.81	98.3
Syn. Yellow Pop 16	42.6	20.3	31.5	19.47	19.44	97.7
Syn. Yellow Pop 17	53.1	22.6	37.9	16.53	16.87	95.3
Syn. Yellow Pop 18	42.1	20.2	31.1	16.66	18.63	98.0
Syn. Yellow Pop 19	40.4	25.0	32.7	17.73	17.97	98.0
Davao Yellow Pop	61.4	37.9	50.3	11.73	14.32	78.0
H. S. D. 0.05	26.7	12.2	14.5	2.55	1.45	7.8
0.01	n.s. a/	14.0	16.4	2.96	1.69	9.0

a/ — Not significant

were highly significantly better than that of Davao Yellow Pop. But among these, Syn. Yellow Pop 6 had a somewhat low yield; all the others had yields which were relatively good, though much lower than that of Davao Yellow Pop.

Plant Characters. Davao Yellow Pop silked the latest in both the wet (together with Syn. Yellow Pop 4) and dry seasons (table 5). The spread in the dry season, however, consisted of only four days, and in the wet season, 5 days. The check also had the tallest plants and the highest ear placement in both seasons. Root-lodging percentage ranged from 27.2 per cent (Syn. Yellow Pop 12) to 49.3 per cent (Davao Yellow Pop). Davao Yellow Pop together with Syn. Yellow Pop Nos. 10, 14, 5, 2, 7 and 12 had the lower percentages of stalk lodging.

Ear and kernel characters. A summary of data on ear and kernel characters is presented in table 6. Davao Yellow Pop had the ear with the highest diameter (3.4 cm.) and a length which was by no means short (15.3 cm.). The ears of Davao Yellow Pop appear-

TABLE 5.—*Days to silking, height, and lodging of 19 yellow-endosperm popcorn synthetics and Davao Yellow Pop during the 1959 wet and the 1959-60 dry seasons*

ENTRY	DAYS TO SILKING		PLANT HEIGHT		EAR HEIGHT		ROOT Lodging	STALK Lodging
	Wet	Dry	Wet	Dry	Wet	Dry		
	days	*days*	*cm.*	*cm.*	*cm.*	*cm.*	*per cent*	*per cent*
Syn. Yellow Pop 1	42	49	196	168	60	52	37.6	10.7
Syn. Yellow Pop 2	43	49	190	184	64	63	27.7	7.9
Syn. Yellow Pop 3	43	49	183	168	75	66	35.4	15.0
Syn. Yellow Pop 4	46	48	189	185	68	61	39.2	12.8
Syn. Yellow Pop 5	44	49	186	176	57	64	42.8	7.3
Syn. Yellow Pop 6	45	47	178	179	65	63	43.2	14.0
Syn. Yellow Pop 7	42	49	182	178	70	52	31.9	8.1
Syn. Yellow Pop 8	44	48	176	185	60	71	44.2	7.3
Syn. Yellow Pop 9	44	49	211	200	78	76	44.2	9.8
Syn. Yellow Pop 10	44	48	193	194	63	79	42.2	6.7
Syn. Yellow Pop 11	44	49	205	178	86	61	31.7	14.4
Syn. Yellow Pop 12	43	49	189	190	61	64	27.2	8.2
Syn. Yellow Pop 13	44	49	190	193	86	76	29.5	17.6
Syn. Yellow Pop 14	45	50	190	199	77	80	38.7	7.2
Syn. Yellow Pop 15	44	49	191	169	63	56	32.9	12.2
Syn. Yellow Pop 16	43	48	194	174	69	58	32.7	10.8
Syn. Yellow Pop 17	44	48	192	187	80	69	28.5	12.5
Syn. Yellow Pop 18	42	46	192	184	70	58	34.8	15.3
Syn. Yellow Pop 19	42	48	196	177	75	64	36.3	13.8
Davao Yellow Pop	46	52	275	225	125	86	49.3	4.2

TABLE 6.—*Summary of ear and kernel characters of 19 yellow-endosperm popcorn synthetics and Davao Yellow Pop during the 1959 wet and 1959-60 dry seasons*

ENTRY	EAR CHARACTERS					FLINTINESS a/
	Kernel		Per cent	Ear		
	Length	Diameter	rows	Shelling	Coverage	
	cm.	*cm.*				
Syn. Yellow Pop 1	14.7	2.8	12-14	81.6	Fair	3
Syn. Yellow Pop 2	15.2	2.9	12-14	80.1	Fair	2
Syn. Yellow Pop 3	13.9	2.8	12	77.9	Fair	2
Syn. Yellow Pop 4	15.5	3.0	14	82.7	Poor	2
Syn. Yellow Pop 5	15.9	2.8	14	77.6	Poor	2
Syn. Yellow Pop 6	16.2	3.0	14	78.0	Fair	2
Syn. Yellow Pop 7	14.8	3.0	12-14	80.1	Fair	3
Syn. Yellow Pop 8	15.8	2.6	12-14	80.4	Fair	2
Syn. Yellow Pop 9	15.4	2.8	12-14	80.5	Fair	3
Syn. Yellow Pop 10	15.8	2.8	12-14	79.5	Fair	2
Syn. Yellow Pop 11	14.5	2.8	12-14	77.6	Fair	2
Syn. Yellow Pop 12	15.1	2.9	12-14	79.2	Fair	2
Syn. Yellow Pop 13	15.1	2.9	12-14	80.9	Poor	2
Syn. Yellow Pop 14	15.9	2.8	12	77.4	Fair	2
Syn. Yellow Pop 15	15.6	2.8	12-14	78.9	Fair	2
Syn. Yellow Pop 16	14.6	2.8	14-16	77.9	Fair	2
Syn. Yellow Pop 17	14.5	2.8	12	79.9	Fair	3
Syn. Yellow Pop 18	14.8	2.8	12-14	78.6	Fair	2
Syn. Yellow Pop 19	13.9	3.1	12-14	78.0	Fair	2
Davao Yellow Pop	15.3	3.4	14-16	83.2	Fair	3

a/ 1 — Very flinty
2 — Flinty
3 — Starchy crowns.

ed much like the ears of small-kerneled flint corn varieties or inbred lines. Syn. Yellow Pop Nos. 1, 7, 9, 17, and Davao Yellow Pop had kernels which were less flinty than the rest of the entries tested. Syn. Yellow Pop Nos. 4, 5, and 13 had ears which were poorly covered. The spread in number of kernel rows was only 4. Syn. Yellow Pop Nos. 3, 14, and 17 had the least with a uniform number of kernel rows of 12.

Pests and diseases. Syn. Yellow Pop 14 was entirely free from earworm damage in the dry-season test. In the wet season, Helminthosporium leaf spot, *Helminthosporium maydis* Nisikado and Miyake, produced severe injury on Syn. Yellow Pop Nos. 7, 12, 13, and 18. Syn. Yellow Pop No. 7 was completely free from rust and injury caused by *Puccinia polysora* Underwd., in the dry season but in the preceding wet season, it had severe injury from this disease. Syn. Yellow Pop Nos. 3, 11, and 17 had high percentages of stalk rot, *Gibberella moniloformis* (Sheldon) Wineland, in the dry season. Syn. Yellow Pop 1 and Davao Yellow Pop seemed to be the most susceptible, however, when a separate planting was made under an epiphytotic of the disease in the 1959 wet-season downy mildew nursery.

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EFFECTS OF TWO SUCCESSIVE IMPLANTATIONS WITH DIFFERENT LEVELS OF SYNTHETIC ESTROGEN ON THE SEXUAL BEHAVIOR AND SUBSEQUENT REPRODUCTIVE PERFORMANCE OF S. C. WHITE LEGHORN AND NEW HAMPSHIRE COCKERELS [1/]

JUAN S. PADILLA AND AMADO C. CAMPOS

WITH EIGHT TEXT FIGURES

Irrespective of the frequency of implantation, 15-mg. diethylstilbestrol treatment of White Leghorn and New Hampshire cockerels temporarily suppressed masculine aggressiveness and caused temporary reduction in testes size and semen volume.

At least two months after treatment with one and two pellets of estrogen, males exhibited both a normal mating behavior and a normal level of fertility. However, a second implantation of two pellets retarded recovery of the development of sexual characters, including the mating behavior and fertility of cockerels.

The implantation of one pellet with the subsequent implantation of either one or two pellets of diethylstilbestrol showed no adverse carry-over effect on the livability of the progeny produced.

Synthetic estrogen implantation is known to reduce temporarily the natural fighting instinct and pugnacity of cockerels raised for breeding. However, little is known about its effect on their reproductive capacity. So far, no work has been reported on their ability to reproduce following a second injection.

The procedure followed by Campos and Fronda (1954) was to inject cockerels with a 15-mg. synthetic estrogen pellet when three months old, the age at which they start to exhibit sexual desires and aggressiveness. The moderating effect of the treatment on sexual behavior and activity lasted for only five to seven weeks. Thus, males treated at an early age recover before they are ready for breeding.

To find out if a second estrogen injection at a dosage the

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same as or bigger than that of the first can suppress the sexual aggressiveness of cockerels during the pre-breeding age without hampering their subsequent breeding capabilities, this study was conducted from August, 1958 to September, 1959, in the Poultry Division, Department of Animal Husbandry.

Synthetic estrogen pellets suppress the comb growth of male birds (Jaap and thayer, 1944; Thayer *et al.*, 1945; Lorenz, 1945; Andrews and Bohren, 1947; Nalbandov and Baum, 1948; Moreng, *et al.*, 1956). The injected estrogen inhibits the secretion of normal levels of gonad-stimulating hormone by the anterior pituitary lobe. This suppressed secretion in turn results in the production of less androgen by the testes, androgen being the hormone that directly induces each comb growth (Kumaran and Turner, 1949).

Estrogen treatment also has an adverse effect on testes size (Andrews and Bohren, 1947; Kumaran and Turner, 1949; Skaller and Grigg, 1950; Lorenz, 1953; and Moreng, *et al.*, 1956). This is also believed to be due to the inhibiting action of injected estrogen on the secretion of gonadotrophic hormone (Moore and Price, 1932; Skaller and Grigg, 1950; and Andrews and Bohren, 1947). As shown by hampered spermatogenesis and marked reduction of semen volume, sexual maturity is delayed, resulting in lower fertility (Akpinar and Shaffner, 1953; Eaton *et al.*, 1955; and Fraps *et al.*, 1956). Campos and Fronda (1954) observed a delay in sexual maturity among White Leghorn roosters, but no reduction in fertility.

Estrogen treatment also affects the sexual behavior of the treated cockerels. Adams and Herrick (1953), Lorenz (1953), and Adams (1955) noted a marked reduction in aggressiveness, a cessation of fighting and crowing instincts, and a loss of sex drive among estrogen-treated cockerels. These workers further observed female mating behavior, such as squatting in treated cockerels as they were approached by the others which have also been treated.

MATERIALS AND METHODS

In two sets of experiments, a total of 180 selected 3-month-old cockerels (90 Single Comb White Leghorns and 90 New Hampshires) were used. These cockerels were leg-banded, and their initial and

biweekly weights taken.

In the first set, 45 cockerels of each breed were divided equally into three lots and given the following treatments: those in lot Ia served as the control: those in IIa were implanted with one 15-mg. diethylstilbestrol pellet at three months of age; and those in lot IIIa were implanted with one 15-mg. diethylstilbestrol pellet at three and five months of age.

In the second set, the same number of lots and cockerels was used but the treatments differed slightly. The cockerels in lot Ib composed the control; those in lot IIb were implanted with two 15-mg. diethylstilbestrol pellets at three months of age; and those in lot IIIb were implanted with one 15-mg. diethylstilbestrol pellet at three months and two pellets at five months. The design of the experiment is shown in table 1.

TABLE .—*Design of Experiment*

NUMBER OF BIRDS PER LOT	LOTS a Ia & Ib 15 W.L.	15 N.H.	LOTS b IIa & IIb 15 W.L.	15 N.H.	LOTS c IIIa &IIIb 15 W.L	15 N.H.
Testes size	5	5	5	5	5	5
Semen quality	5	5	5	5	5	5
a. semen volume						
b. semen density						
c. sperm motility						
Fertilizing ability	5	5	5	5	5	5
TOTAL	15	15	15	15	15	15

a/ Not injected.

b/ Each cockerel in lot IIa was injected with one pellet at 3 months, and in lot IIb with two pellets.

c/ Each cockerel in lot IIIa was injected with one pellet at 3 and 5 months of age, and in lot IIIb, one pellet at 3 and two pellets at 5 months of age.

The birds in each lot in both experiments were kept in separate 5 x 6-feet elevated houses having 4 x 6-feet sun porch. They were fed an all-mash growing ration until they were 24 weeks of age and an all-mash breeding ration afterwards.

At seven months of age, cockerels of both breeds in each lot in both experiments were randomized into three groups, each with five birds. One group was sacrificed so that the weights of their testes

could be determined. Testes of individual birds were weighed in a torsion balance to the nearest hundredth of a gram.

The second group of cockerels was used for semen quality studies, and the third for fertility. Of the cockerels in the second group, three were picked at random and placed in individual cages and trained for semen collection. Semen was collected from them weekly for 18 weeks, using the massage technique described by Burrows and Quinn (1937). The volume of semen was measured and the motility examined under the microscope immediately after collection. Motility was rated from 1 to 5 based on a modified rating by Smith (1949). The density of sperms was determined every collection time with the use of a haemacytometer, using the average of three counts.

Two cockerels of each breed from the third group were mated with 30 laying pullets of the same breed for observation on mating behavior and fertility. The capability of the cockerels to mate, as measured by the number of matings each day, was recorded a day after the cockerels were introduced into the pen of the pullets. The mating behavior on the first day was abnormal: cockerels exhibited over-anxiety and did not successfully mount the pullets. Changes in sexual behavior were observed daily until the end of the experiment.

Fertility was determined by the daily incubation of all normal eggs laid for two weeks. Settings were made weekly thereafter. After seven days of incubation, the eggs were candled and any egg in which the embryo was not distinctly developed was opened so that its fertility could be confirmed.

RESULTS AND DISCUSSION

Changes in comb size and sexual behavior. In the first experiment, the combs of six White Leghorn and four New Hampshire cockerels shriveled and became pale three days after the estrogen implantation. At the start of the second week, the combs and wattles of all the cockerels of both breeds in the experimental lots showed the same effect.

In addition to th adverse effect on comb size, the treated birds showed a progressive reduction in activity and aggressiveness. At

the end of the second week, treated cockerels of both breeds lost their sexual libido; some individuals exhibited female behavior such as squatting when approached. These observations corroborate the findings of Adams and Herrick (1953-1955), Lorenz (1953), Akpinar and Shaffner (1953), and Eaton *et al.* (1955).

The combs and wattles of some treated cockerels re-enlarged and reddened as early as the later part of the fourth week after implantation. Except for two White Leghorn and one New Hampshire cockerels, the treated birds exhibited a reversion of their comb size to normal seven weeks after treatment. Campos and Fronda (1954) previously reported that estrogen-treated cockerels recovered as early as the fifth week after treatment.

In the second experiment, changes in the comb size and sexual behavior of the treated birds followed the same pattern as in the first experiment, except that lot IIb cockerels responded faster to the treatment and recovered more slowly. Most of the lot IIb birds, which had been implanted with two pellets at three months of age, exhibited a drying up of their combs three days later, and a re-enlargement and reddening of the combs eight weeks after implantation. Normal sexual behavior as shown by fighting and a tendency to mount other males was observed on the ninth week.

During the first eight weeks, the effect of the first estrogen implantation on comb size and behavior of cockerels in lot IIIb was similar to that observed in lots IIa and IIIa which had been injected with one pellet each in the first treatment. However, on the second implantation (of two pellets this time), lot IIIb combs shrank faster but recovered more slowly than lot IIIa. Combs and wattles in lot IIIb dried up on the 5th day and in lot IIIa on the 7th day after the second implantation. The recovery from the second treatment of the birds in lot IIIb was slow: some treated cockerels did not fully recover eight weeks after the implantation. On the other hand, all the lot IIIa birds recovered on or before the eighth week. Moreng *et al.* (1956) also reported that as estrogen dosage was increased and repeated, the degree of response to the treatment increased correspondingly and the rate of recovery became slower.

Testes size. The effect of the treatments on testes size two (lot IIIa and lot IIIb) and four months (lot IIa and lot IIb) after

implantation is shown in table 2a for experiment I and in table 2b for experiment II. In both experiments and for both breeds, the

TABLE 2[a]. — *Weight of testes two to four months after estrogen implantation in experiment I*[a]

BIRD NUMBER	S. C. WHITE LEGHORN			NEW HAMPSHIRE		
	Lot Ia (Control)	Lot IIa (One implantation of 1 pellet)	Lot IIIa (Two implantations of 1 pellet each)	Lot Ia (Control)	Lot IIa (One implantation of	Lot IIIa (Two implantations of 1 pellet each)
	gram	*gram*	*gram*	*gram*	*gram*	*gram*
1	12.6	8.8	3.2	29.3	28.5	4.4
2	17.6	14.4	11.2	25.5	21.6	5.2
3	19.6	12.9	5.6	34.6	8.2	10.7
4	18.8	9.4	4.6	30.6	15.3	5.7
5	15.3	12.8	2.2	30.7	31.6	8.1
Average	16.7	11.7	5.4	30.2	21.0	6.8

[a]/ Weights of testes were taken at the age of 7 months, two months after implantation in lot III, and four months after in lot II.

TABLE 2b. — *Weight of testes two to four months after implantation in experiment II*[a]

NUMBER OF DRESSED BIRDS	S. C. WHITE LEGHORN			NEW HAMPSHIRE		
	Lot Ib (Control)	Lot IIb (One implantation of 2 pellets)	Lot IIIb (Two implantations of 1 and 2 pellets)	Lot Ib (Control)	Lot IIb (One implantation of 2 pellets)	Lot IIIb (Two implantations of 1 and 2 pellets)
	gram	*gram*	*gram*	*gram*	*gram*	*gram*
1	19.4	3.5	2.6	20.6	6.9	7.2
2	15.7	9.8	5.4	21.8	7.7	4.4
3	18.3	7.2	3.8	28.3	9.6	1.8
4	16.8	6.2	1.3	26.7	7.4	6.1
Average	17.5	6.7	3.3	24.4	7.9	4.9

[a]/ Weights of testes was taken at the age of 7 months.

greater the dosage and frequency of estrogen implantation the greater was the degree of reduction and the slower the rate of recovery of the testes. Differences in testes size of birds kept in the different lots in the same or in both sets of experiments were highly significant, except between lots IIIa and IIIb and between control groups in experiments I and II, which were insignificant.

According to Kumaran and Turner (1949) and Nalbandov and

Baum (1948), feeding or implanting estrogen on male birds always brings about a reduction in the size of the testes. Lorenz (1953) and Moore and Price (1932) explained that the depression in testes size and function as a result of estrogen treatment was due to the inhibition of the secretion of gonadotrophic hormones by the pituitary lobe of the treated birds. Without the needed hormonal stimulation, the testes shrank and decreased in function.

To find out if testes size of treated cockerels would return to normal if given ample time to recover, three apparently recovered birds were selected and sacrificed at the end of the study (six to ten months after implantation). Data for experiment I are in table 3a and those for experiment II in table 3b. Irrespective of the

TABLE 3a. — *Weight of testes six to ten months after implantation in experiment I*

NUMBER OF DRESSED BIRDS	S. C. WHITE LEGHORN			NEW HAMPSHIRE		
	Lot Ia (Control)	Lot IIa (One implantation of 1 pellet	Lot IIIa (Two implantations of 1 pellet	Lot Ia (Control)	Lot IIa (One implantation of 1 pellet each)	Lot IIIa (Two implantations of 1 pellet each)
	gram	*gram*	*gram*	*gram*	*gram*	*gram*
1	21.9	18.9	17.7	27.4	28.2	22.9
2	18.5	17.4	20.5	24.8	21.6	27.5
3	16.3	18.1	15.4	27.3	27.4	25.4
Average	18.8	18.1	17.8	26.5	25.4	25.3

TABLE 3b. — *Weight of testes six to ten months after implantation in experiment II*

NUMBER OF DRESSED BIRDS	S. C WHITE LEGHORN			NEW HAMPSHIRE		
	Lot Ib (Control)	Lot IIb (One implantation of 2 pellets)	Lot IIIb Two implantations of 1 and 2 pellets)	Lot Ib (Control)	Lot IIb (One implantation of 2 pellets)	Lot IIIb Two implantations of 1 and 2 pellets)
	gram	*gram*	*gram*	*gram*	*gram*	*gram*
1	17.2	16.6	17.5	30.8	27.5	26.7
2	22.8	19.3	16.2	24.7	23.9	25.9
3	18.4	18.9	19.6	25.4	28.6	24.2
Average	19.4	18.3	17.4	27.0	26.9	25.6

dosage of estrogen implanted, testes size tended to return to normal if given a reasonable period of time to recover.

Semen volume and quality. The effect of estrogen implantation on the potential reproductive capacity of the cockerels was studied in experiments I and II by making weekly collections of semen from the treated and untreated cockerels. Semen was first collected at 7 months of age, or four months after implantation, from lots IIa and IIb, and two months after the last implantation from lots IIIa and IIIb. The average weekly volume of semen collected is presented in figures 1a and 1b for experiment I and figures 2a and 2b for experiment II. In both experiments, semen production of treated cockerels of both breeds remained subnormal during the 18-week collection period. In experiment I, semen production of lot IIIa birds tended to be only half as much as that of the control and that of lot IIa tended to lie midway between those of lot IIIa and the control. On the average, semen collected per ejaculation from each of the White Leghorns was 0.36 ml. for lot Ia, 0.26 ml. for lot IIa, and 0.18 ml. for lot IIIa. The corresponding average semen volume of the New Hampshires was: 0.40 ml. for lot Ia, 0.32 ml. for lot IIa, and 0.27 ml. for lot IIIa. Differences between lots were significant. Treated birds in experiment II produced less semen than those in experiment I. The average semen volume of the White Leghorns in the second experiment was 0.39 ml. for lot Ib, 0.24 ml. for lot IIb, and 0.20 ml. for lot IIIb. The corresponding figures for the New Hamoshires was 0.46 ml. for lot Ib, 0.25 ml. for lot IIb, and 0.21 ml. for lot IIIb. Differences between treated and untreated lots were highly significant but differences between treated lots were not marked.

In the charts for experiment I, it will be noted that semen production of cockerels of both breeds in lots IIa and IIIa exhibited an upward trend at the beginning of the collection period and tended to level off a month or so later. On the other hand, semen production in experiment II tended to be uniformly low from the beginning till the end of the 18-week collection period. This apparently indicates that the dosage and frequency of estrogen implantation adversely affected subsequent semen production.

The quality of the semen produced by cockerels in the two sets of experiments was studied, using initial motility rating and sperm count as criteria. The data obtained show no significant differences between lots regardless of the dosage of estrogen used. According to Lorenz (1953), estrogen caused temporary cessation of spermato-

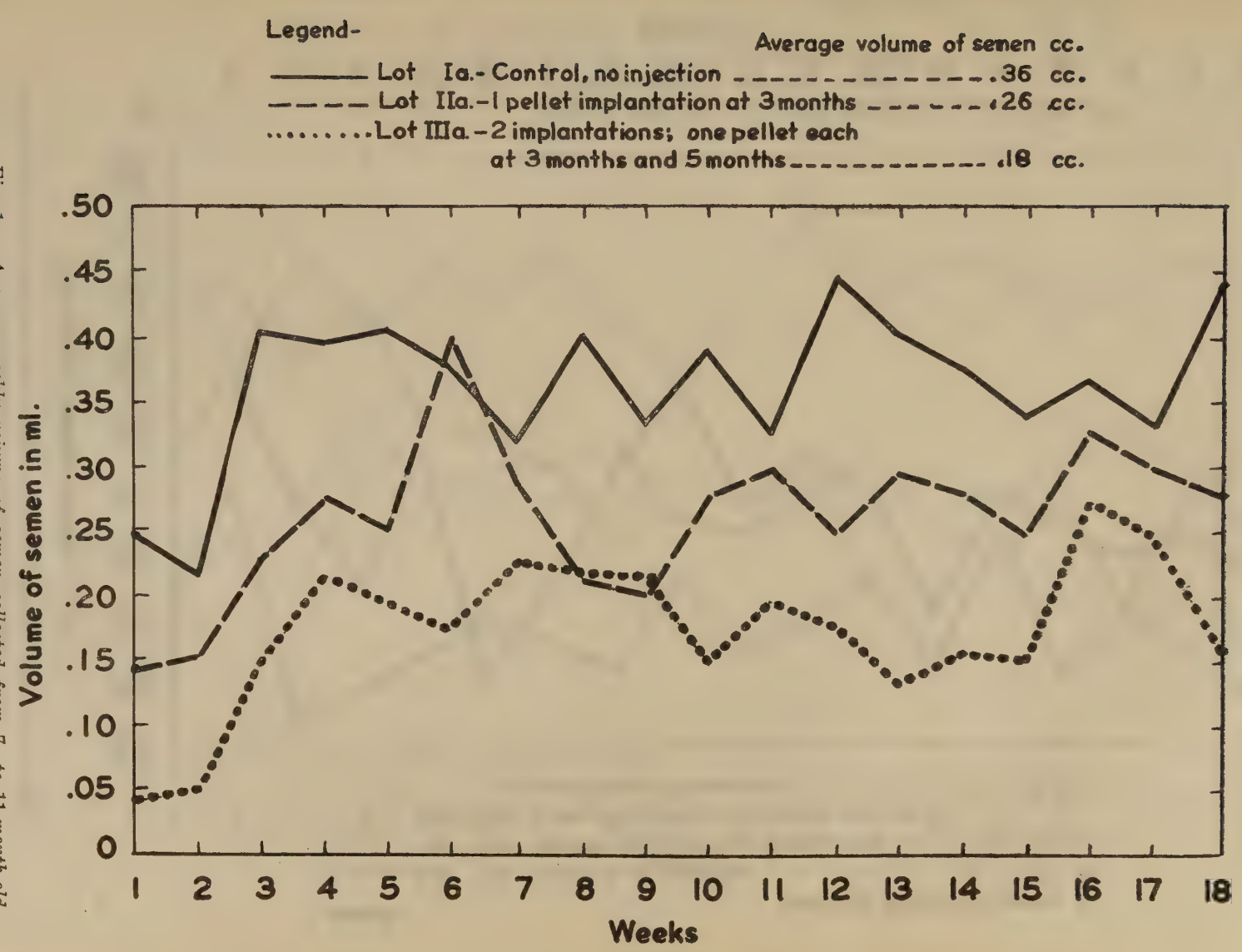

Fig. 1a.—*Average weekly volume of semen collected from 7- to 11-month-old White Leghorn cockerels in experiment I.*

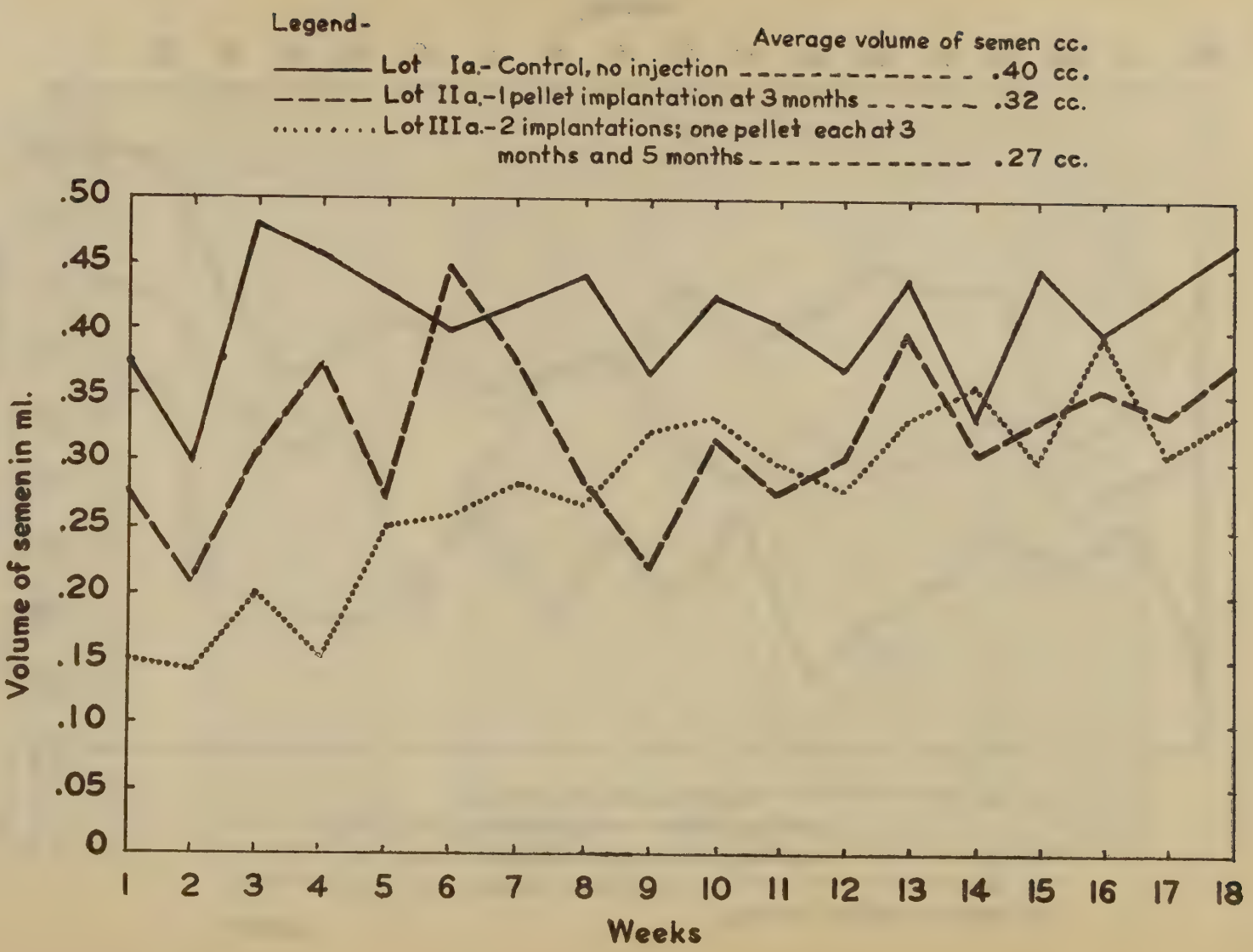

Fig. 1b.—*Average weekly volume of semen collected from 7- to 11-month-old New Hampshire cockerels in experiment I.*

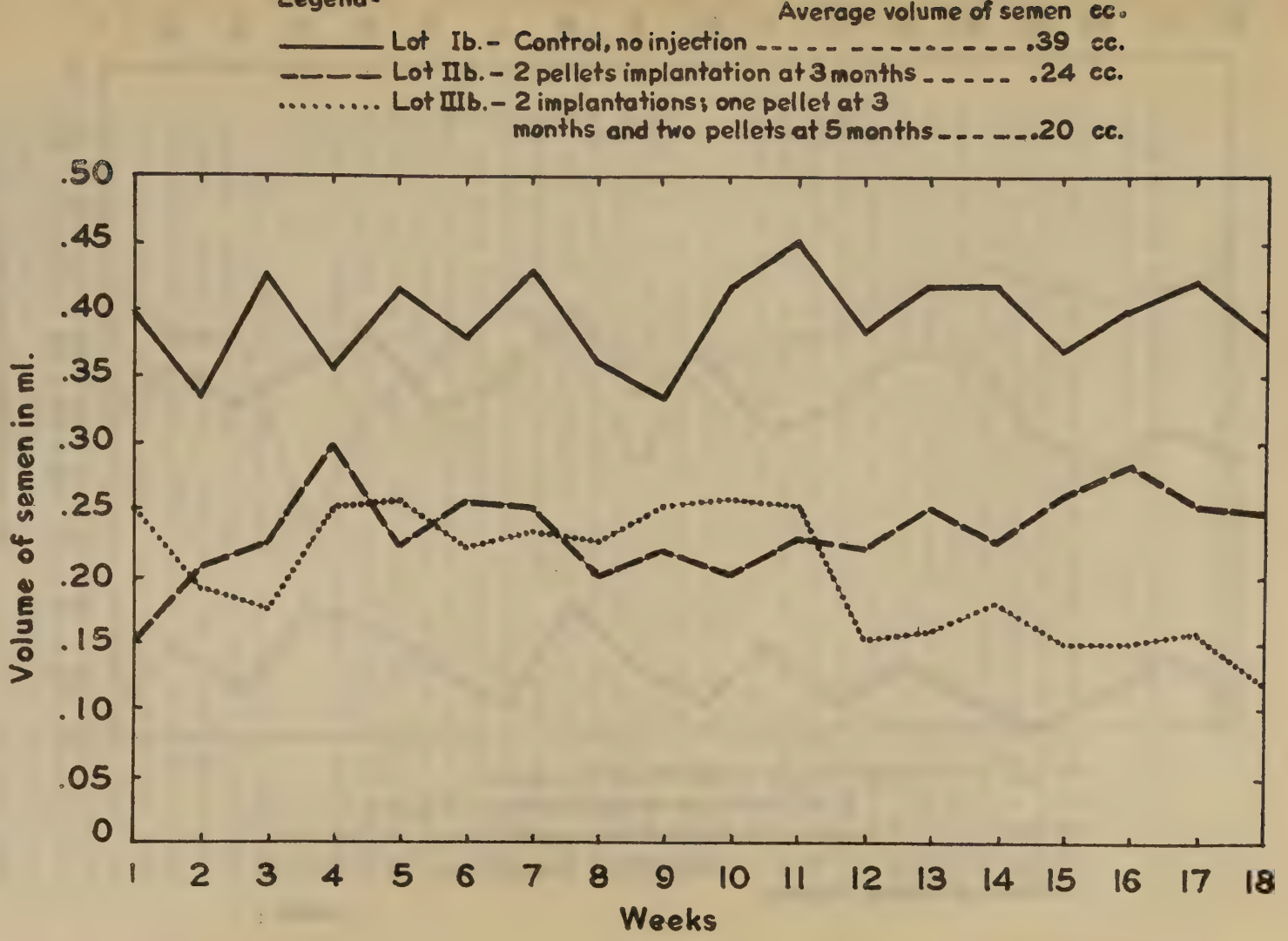

Fig. 2a.—*Average weekly volume of semen collected from 7- to 11-month-old White Leghorn cockerels in experiment II.*

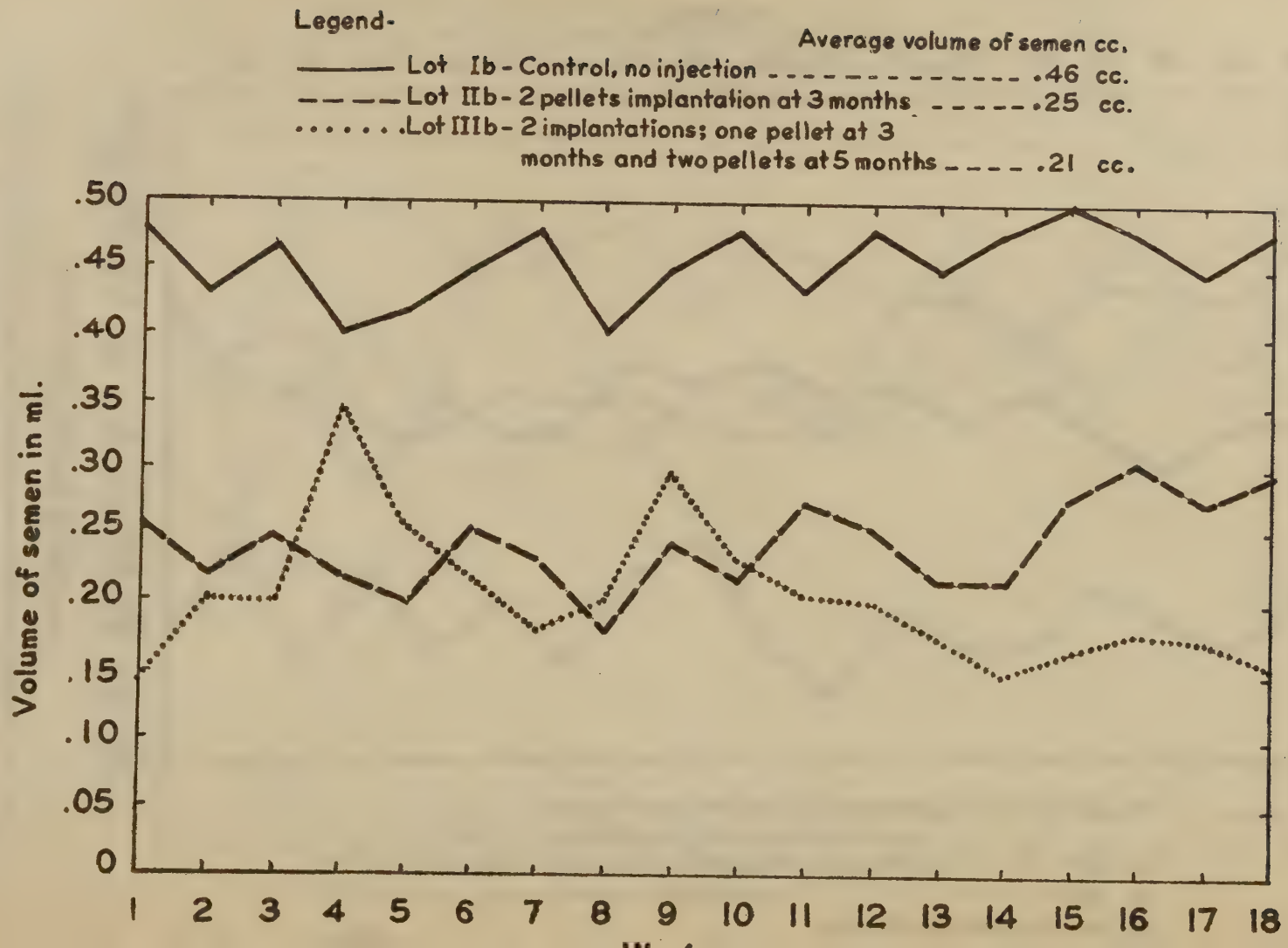
Legend-
Average volume of semen cc.
Lot Ib - Control, no injection .46 cc.
Lot IIb - 2 pellets implantation at 3 months .25 cc.
Lot IIIb - 2 implantations; one pellet at 3 months and two pellets at 5 months .21 cc.
Volume of semen in ml.
.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Fig. 2b.—*Average weekly volume of semen collected from 7- to 11-month-old New Hampshire cockerels in experiment II.*

genesis, and of normal production of motile sperm three to four weeks after the treatment.

Data for weekly sperm count or sperm concentration in experiment I show that in the White Leghorn lots, the average at the end of the experiment in lot Ia was 5.1 million sperms per c.c.; lot IIa, 4.9 million, and lot IIIa, 4.8 million. Among the New Hampshire lots, Ia had an average of 5.1 million, lot IIa, 4.9 million and lot IIIa, 5.1 million. Differences among the lots were insignificant. These indicate that the estrogen treatment had no permanent harmful effect on the ability of the gonads of cockerels to maintain the normal sperm concentration of their semen. The number of sperms produced in the treated lots was still within the normal counts of semen produced by untreated cockerel, which range from 825,000 to 7,000,000 sperms per ml. (Taylor, 1949).

The corresponding average sperm counts for the White Leghorns in the second experiment were as follows: lot Ib, 4.8 million; lot IIb, 4.7 million; and lot IIIb, 3.0 million. Among the New Hampshires, lot I b had an average of 4.8 million; lot IIb, 4.4 million; and lot IIIb, 2.8 million. The sperm counts in lots IIIb of both breeds were significantly lower than those in the other lots in experiment II or in experiment I. The great reduction in the concentration or density of sperms in lot IIIb could be attributed to the large dosage of estrogen used during the second implantation. It is possible that the testes had not fully recovered from the adverse effect of the treatment when semen samples were collected. According to Herrick and Adams (1956), successive implantations with higher dosages of estrogen would prolong the cessation of spermatogenesis in the treated cockerels and reduce spermatozoa.

Mating ability of recovered males. The ability to mount the hens and copulate was used in measuring mating ability. Two cockerels selected at random from each lot in both experiments were mated with 30 females. The number of times each of the cockerels mounted was then recorded for three consecutive days, starting a day after they were mixed with the females. Tables 4a and 4b show the average number of successful matings observed in both experiments. In experiment I there was no consistent trend to indicate any adverse effect of the treatment on the frequency of matings. In experiment II, however, the cockerels exhibited prog-

TABLE 4a.— *Average number of matings observed in experiment I*[a]

DAY	S. C. WHITE LEGHORN			NEW HAMPSHIRE		
	(Control) Lot Ia	Lot IIa (One implantation of 1 pellet)	Lot IIIa (Two implantations of 1 pellet) each)	Lot Ia (Control)	Lot IIa (One implantation of 1 pellet)	Lot IIIa (Two implantations of 1 pellet) each)
1	25	23	14	29	23	29
2	16	18	17	22	21	26
3	20	22	20	23	26	27
Average	20.3	21.0	17.0	24.7	23.3	27.3

[a]/ Average count of matings of two cockerels from each lot for three consecutive days, starting a day after the cockerels were placed inside the pen.

TABLE 4b.— *Average number of matings observed in experiment II*[a]

DAY	S. C. WHITE LEGHORN			NEW HAMPSHIRE		
	(Control) Lot Ib	Lot IIb (One implantation of 2 pellets)	Lot IIIb (Two implantations of 1 and 2 pellets)	Lot Ib (Control)	Lot IIb (One implantation of 2 pellets)	Lot IIIb (Two implantations of 1 and 2 pellets)
1	20	16	14	21	14	13
2	18	21	13	20	16	13
3	21	17	12	24	21	16
Average	19.7	18.0	13.0	21.7	17.0	14.0

[a]/ Average count of matings of two cockerels from each lot for three consecutive days, starting a day after the cockerels were placed inside the pen.

ressive reduction in the number of matings, which was inversely proportional to the dosage of hormone injected. Successful copulations in the treated lots were fewer because a number of hens refused to be mounted by the recovered males. In several instances the hens were even observed to fight the cockerels before mating. This unusual behavior of the hens may be attributed to the deceptive appearance of the recovered males. The presence of many hen feathers on the treated cockerels, particularly those of lot IIIb, made them appear unacceptable.

Fertility of eggs produced by pen mates. The final test of the effect of the treatment on the breeding qualities of the recovered

males is the fertility of the eggs produced by their pen mates. Eighteen weekly settings were made, involving 4,100 White Leghorn eggs and 3,799 New Hampshire eggs in experiment I and 2,535 White Leghorn eggs and 2,513 New Hampshire eggs in experiment II. The results are presented in figures 3a and 3b for experiment I and figures 4a and 4b for experiment II. The treated New Hampshire males in experiment I had approximately the same level of fertility rating as the control. In the White Leghorn group, the lot IIIa cockerels had consistently lower fertility than the control during the first 15 settings, with lot IIa males approximating that of the untreated lot in all the 18 settings. The somewhat high fertility of lot IIIa New Hampshires compared with the corresponding White Leghorn lot may be due to breed differences. It is probable that, in spite of the reduction in the volume of semen produced, the New Hampshire cockerels in lot IIIa recovered from the treatment to such an extent that they effected normal fertility; such was not the case with the corresponding lot of White Leghorns.

Results in experiment II for both breeds followed closely that for the White Leghorn in experiment I except that the drop in the fertility of lot IIIb was more marked and was progressive. With both breeds in experiment II, fertility of lot IIIb birds did not rise above 60 per cent during the entire 18-week observation period. The lowest figures recorded for both breeds were 7.3 per cent for White Leghorn and 6.5 per cent for New Hampshire; both were obtained from the 12th week settings.

The fertility ratings in experiment I averaged as follows: for the White Leghorn, lot Ia, 89.4 per cent; lot IIa, 85.4 per cent; and lot IIIa 70.5 per cent; and for the New Hampshire, lot Ia, 95.2 per cent; lot IIa, 93.9 per cent; and lot IIIa, 94.8 per cent. In experiment II the corresponding figures were 84.7 per cent in lot Ib, 81.6 per cent in lot IIb, and 24.5 per cent in lot IIIb for the White Leghorn, and 88.0 per cent in lot Ib, 88.7 per cent in lot IIb and 28.6 per cent in lot IIIb for the New Hampshire.

By and large, the 3-pellet injection caused marked reduction of the fertility of the males. This is borne out by the results obtained not only from fertility tests but also from studies on sperm count, semen volume and testes size. This great reduction in fer-

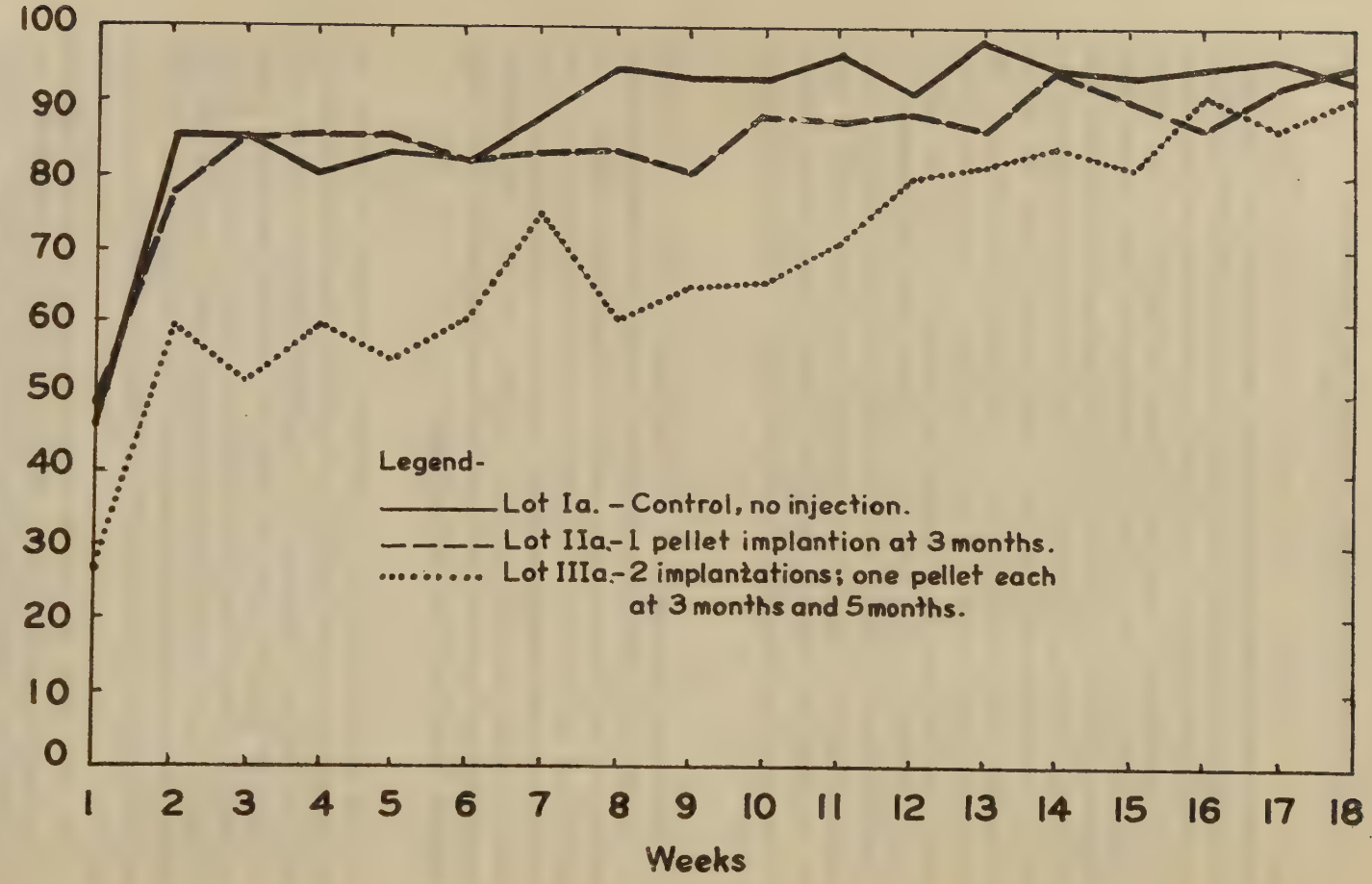

Fig. 3a.—*Weekly percentage of fertility of S.C. White Leghorn eggs in experiment I.*

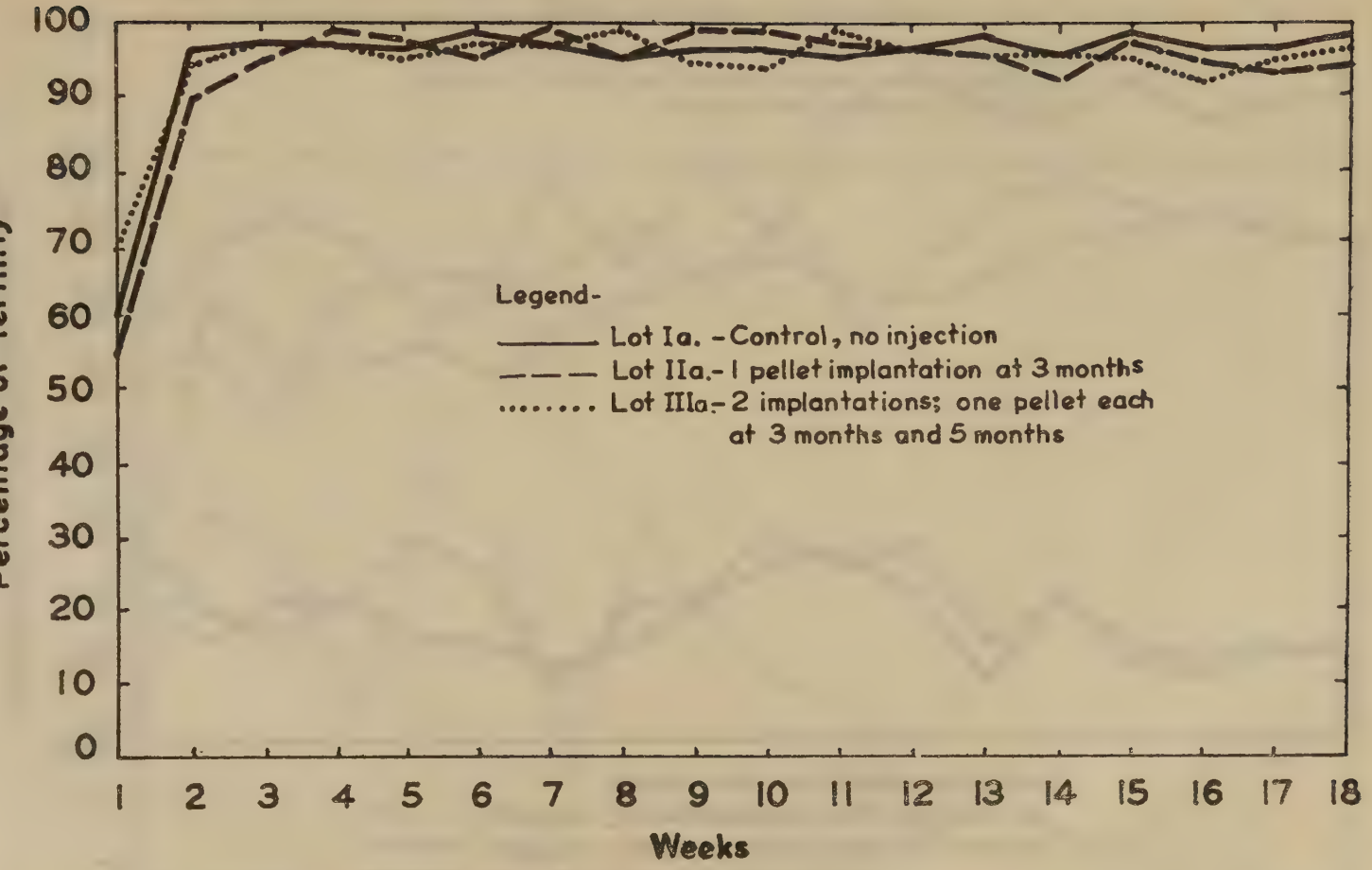

Fig. 3b.—*Weekly percentage of fertility of New Hampshire eggs in experiment I.*

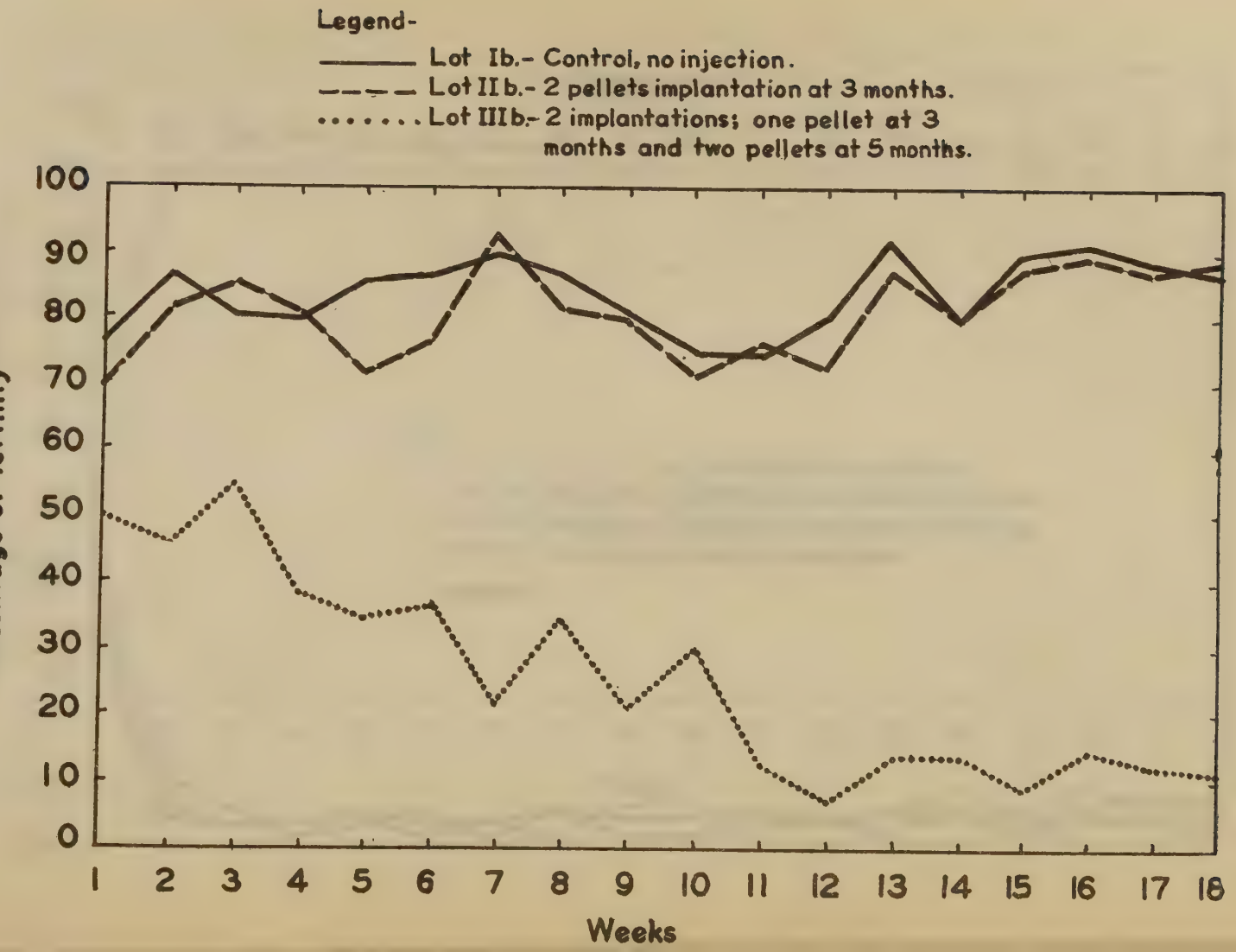

Fig. 4a.—*Weekly percentage of fertility of S.C. White Leghorn eggs in experiment II.*

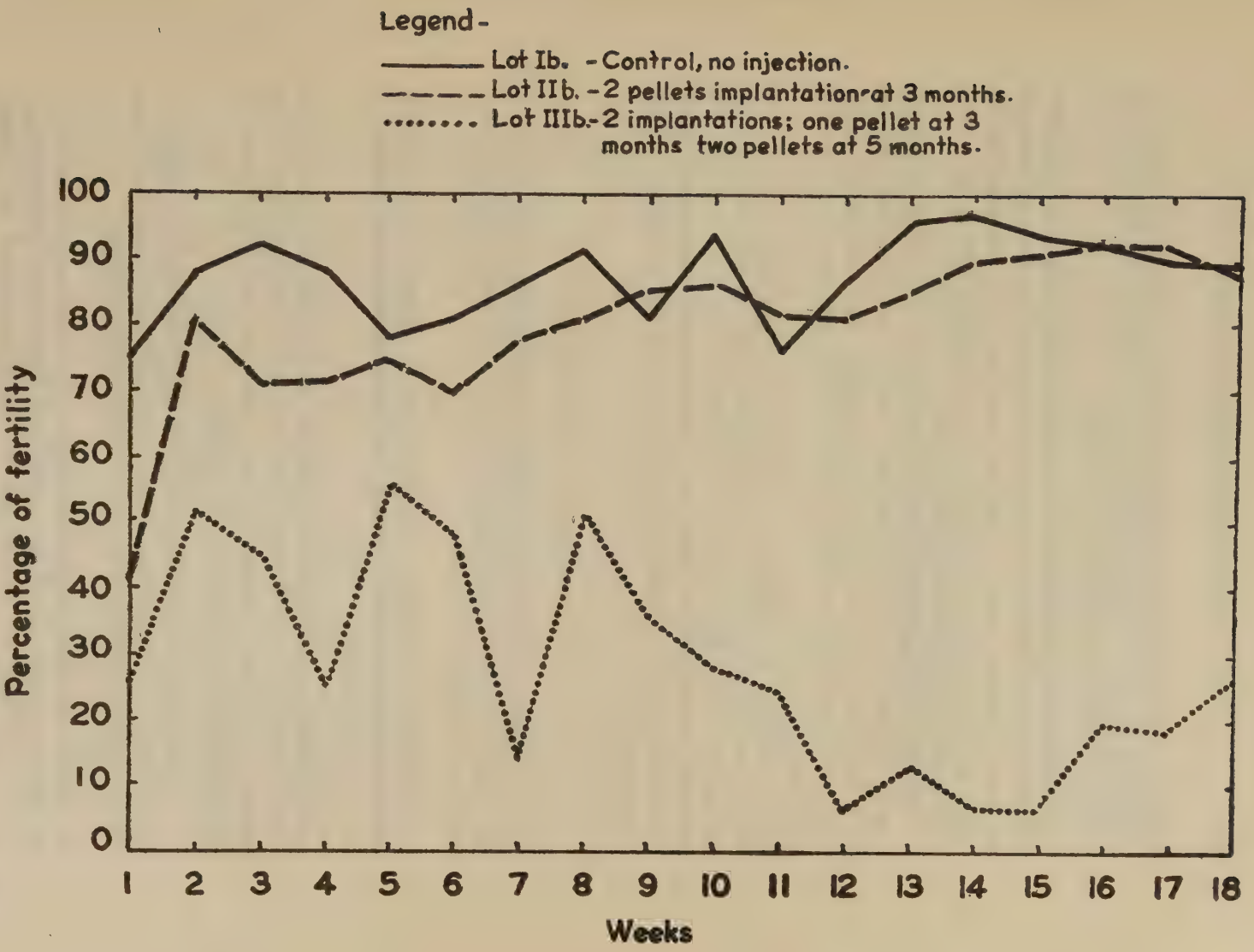

Fig. 4b.—*Weekly percentage of fertility of New Hampshire eggs in experiment II.*

tility among the treated cockerels implanted with three pellets in both breeds may be attributed to the prolonged adverse effect of a large dosage of estrogen in the testes.

Percentage of mortality of resulting offspring. To find out if the estrogen treatment of males would affect the rate of livability of their offspring, some of the fertilized eggs in both experiments were hatched and the mortality of the chicks during the first three-week period was observed.

In the first experiment, the mortality for the White Leghorn was as follows: lot Ia, 18.1 per cent; lot IIa, 15.2 per cent; and lot IIIa, 17.3 per cent. For the New Hampshire the mortality was as follows: lotIa, 9.6 per cent; lot IIa, 9.2 per cent; and lot IIIa, 9.8 per cent.

In the second experiment, with White Leghorns, lot Ib had 9.9 per cent mortality; lot IIb, 7.3 per cent; and lot IIb, 9.7 per cent. Among the New Hampshire, lot Ib had 9.4 per cent; lot IIb, 7.6 per cent; and lot IIIb, 9.7 per cent. These figures conclusively show that there was no carryover adverse effect of the treatment on the offspring.

SUMMARY AND CONCLUSIONS

1. Estrogen implantation effectively but temporarily inhibited the aggressiveness and fighting tendency of the cockerels, thus making management easier.

2. Single or successive implantations of estrogen did not affect subsequent mating behavior except in males subsequently implanted with higher dosage.

3. Estrogen implantation reduced testes size and semen volume regardless of the dosage or the number of implantations. The reduction in semen volume, however, was not closely followed by a corresponding reduction in testes size.

4. Estrogen implantation did not affect the initial motility of the sperms but successive implantations affected sperm concentration, more so in males treated with higher dosage.

5. The recovery of treated males was as fast as the effect. As the dosage was increased, the effect was fast but the recovery slow.

6. Implantations of one pellet of diethylstilbestrol and implan-

tation of two pellets delayed a little the time necessary for the treated males to effect maximum fertility. However, the recovered males were as efficient as the untreated males in effecting normal level of fertility if given sufficient time to recover from the adverse effect of estrogen. The implantation of one pellet with subsequent implantation of two pellets brought about a very low level of fertility.

7. The implantation of one pellet with subsequent implantation of one or two pellets had no carry-over adverse effect on the livability of the progeny.

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NOTE: A NEW VIRUS DISEASE OF BLACK PEPPER (*PIPER NIGRUM* L.)

MARIA SALOME DEL ROSARIO

WITH TWO TEXT FIGURES

A black pepper plant showing characteristic symptoms of a virus disease was referred to the writer by Mr. L. Bondoc of the Department of Agronomy, U.P. College of Agriculture, for determination of its possible cause.

Fig. 1.—*Diseased black pepper plant submitted by Mr. L. Bondoc of the Department of Agronomy, showing slightly thickened small and malformed leaves accompanied by yellow mottling.* (Photographed by the Photographic Division)

SYMPTOMS OF THE DISEASE

The diseased plant was undersized with its leaves slightly thickened, misshapened, and accompanied by yellow mottling. In some leaves, general chlorosis developed (fig. 1).

Microscopic examinations and cultural studies of the roots, stems and leaves failed to reveal any bacteria, fungi, and nematodes that may have caused the diseased condition.

TRANSMISSION

Initial attempts to transmit the virus from the diseased black pepper plant to healthy ones by manual inoculation using crude sap and by a leafhopper, *Colgar sp.* produced negative results. After repeated failures to transmit the virus using the above methods, other means were employed.

Fig. 2.—*Left: Black pepper plant infected through transmission by inarching showing deformed and highly reduced leaves and general stunting, giving a bushy appearance. Right: Healthy control, showing normal size of plant parts.* (Photographed by S. del Rosario)

The disease was finally transferred to healthy plants by inarching. Results of five trials gave a 100 per cent transmission with this method. The first visible symptom of the disease was a clearing of the veins, which appeared 28 to 35 days after inarching. As the disease progressed, the leaves became thick and were reduced in size. On the succeeding leaves, the plant exhibited general stunting, giving a bushy appearance. The inoculated plant showed symptoms similar to that of the original diseased plant. On the other hand, the control plant remained healthy (fig. 2).

Preliminary results of this experiment strongly indicate a viral agent as the cause of the disease on black pepper. This disease seemed to be identical with the "pepper stunt" reported by Halliday [1] in Sarawak, Borneo, which was caused by a virus. This is the first report of such a disease on this plant in this country. Various experiments regarding the nature, possible vectors and other methods of transmitting the disease are in progress.

1/ P. Halliday, Commonw. Phytopath. Virus 5:49-52 (1959). As cited by J.C.F. Hopkins, 1960.

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